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speedwave® four

Microwave Digestion System with Built-in, Non-Contact Temperature and Pressure Measurement

v. 1.0

User Manual



realizing
your
ideas.

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Notes regarding this Handbook

Contents:

This handbook describes the microwave pressure digestion system **speedwave four**. It contains product specific information, current as of the date of publication of this handbook. This technical documentation is a reference and instructional manual. Each chapter is complete in and of itself.

This handbook guides the user in the safe and proper use of **speedwave four** system. Familiarity with the relevant chapters of this handbook is required for safe and intended use of the equipment

Read this instructional manual carefully prior to operating the equipment. After unpacking, carefully check the equipment for mechanical damage and missing parts. Should you find any damage incurred during shipment, contact the manufacturer immediately and do not operate the equipment.

This instructional manual does not include repair instructions. Should repairs be required, please contact your dealer or Berghof Products + Instruments GmbH.

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SW-4_53-0170-93-00-00-002

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Berghof Products + Instruments GmbH are certified in accordance with DIN EN ISO 9001:2000.

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1. General Notes

Please read this instruction manual carefully before operating your high pressure digestion system. Failure to follow these instructions could result in damage to the equipment as well as personal injury.

Safety instructions are printed in **boldface** throughout and shown as illustrated in section '*Danger Categories and Signal Words*'. These safety notes must be heeded in all cases!

1.1. Danger Categories and Signal Words

The signal words described below are used in connection with warnings throughout this manual. For your own safety and to avoid property damage, you must strictly heed these warnings!

The safety signals are printed in boldface or are otherwise marked throughout this manual and have the following meanings:



DANGER !

Means that failure to follow the safety instructions is likely to cause severe personal injury, death or severe property damage.



Warning !

Means that failure to follow the safety instructions may cause severe personal injury, death or severe property damage.



Caution

Means that failure to follow the safety instructions may cause personal injury or some property damage.



Note:

This symbol indicates that this is important information regarding the product or refers to a part of the manual, which requires particular emphasis.

1.2. Qualified Users

Only Qualified Users should operate this equipment. Qualified Users with respect to this manual are relevantly schooled and trained specialists with a basic knowledge of chemistry. They should be trained in the safe handling of chemicals.

1.3. Proper Use



DANGER ! **Explosion hazard!**

The unit is not designed for extraction and metabolization procedures employing organic solvents.



Warning ! **Observe all operating instructions!**

Since sample composition is generally not precisely defined, a certain residual risk exists when performing pressure digestion processes. Careful working practices and conscious compliance with safety regulations can only minimize this risk, not totally eliminate it. Due to different degrees of mixing, even identical samples can exhibit totally different behaviors during the course of the reaction!

Please strictly comply with the operating instructions, particularly when handling the pressure vessels, that is, when removing and opening the vessels. Incorrect handling of the hot, pressurized vessels can result in injuries from escaping acid vapors!

The **speedwave** microwave digestion system has been designed to perform chemical digestion procedures under extreme pressure and temperature conditions in chemical laboratories. Digestion is understood to mean the decomposition of a solid material by means of a suitable digestion reagent at increased temperature in a vessel that is permeable with regard to microwaves. The digestion solutions are directly heated through the absorption of the microwave radiation by the polar digestion reagent, which generally also contains ionic components.

Digestion reagents used include nitric acid (65%), hydrochloric acid, hydrofluoric acid, phosphoric acid, and sulfuric acid, as well as mixtures of these acids. The maximum initial weight for organic compounds depends on the digestion vessel being used and the sample's carbon content, must always be observed. The use of organic solvents is strictly prohibited in microwaves since the spontaneous combustion of any solvent vapors that escape into the oven chamber cannot be precluded.

Heating in the pressure vessel results in digestion temperatures in excess of 200 °C (392 °F). The **speedwave** has been specially developed for sample preparation for AAS and ICP spectroscopy procedures. Very temperature spikes >280 °C (>536 °F) such as can occasionally occur during the course of exothermic reactions can result in irreversible damage to the Teflon vessels. Since such scorching cannot always be avoided, even with optimum microwave power regulation, damage of this kind is excluded from the warranty! When quartz glass inserts are employed, the greatest care must be taken when handling the glass as even the slightest amount of damage to the surface can greatly diminish surface strength. For this reason, glass components are excluded from the warranty!

Adapters for evaporating and concentrating digestion solutions are optionally available for all vessel types.

Qualified handling and, possibly, proper transport, storage, set-up, and use, as well as conscientious maintenance are all prerequisites for the trouble-free and safe operation of the **speedwave** microwave digestion system.

The system may only be used within the context of data and applications specified in this documentation and the associated user manuals.

The digestion system may only be used:

- Properly;
- In a technically flawless condition;
- Without unauthorized alterations or modifications;
- By qualified users.

Please also observe all regulations published by professional/trade associations, the TÜV, VDE regulations, or corresponding national regulations.

1.4. General Safety Information

Performing microwave digestion procedures involves taking into account various safety precautions which go beyond those for general laboratory practices. The following general safety information should therefore be read carefully prior to using the system, and should be observed at all times.

The following information must be complied with when working with the associated digestion vessels!

We can assume no liability for damages resulting from improper handling of a failure to comply with this information.



Warning !

Always wear eye protection!

Always wear safety glasses/goggles and protective gloves during work which may involve contact with chemicals, that is, when working with acids, pressure vessels, during cleaning, etc.!



DANGER !

Explosion hazard!

Do not use perchloric acid.

No organic solvents (alcohols, hydrocarbons, etc.) may be placed in the pressure vessels or the microwave.

Highly reactive substances which spontaneously react at higher temperatures or in the presence of oxidizing agents or which may be nitrated and are potentially explosive may not be digested in the microwave. Examples of such substances include: explosives (TNT, etc.), perchlorates, ether, pyrophoric substances, etc.

**DANGER ! Pressure vessels!**

Use only digestion vessels and spare parts authorized by Berghof Products + Instruments GmbH for use with the **speedwave**. These can be obtained either from your local dealer or directly from Berghof Products + Instruments GmbH (Refer to the "Repairs / Customer Service" section for contact addresses).

Always wear safety glasses/goggles and protective gloves when working with the pressure vessels!

Note any changes in the appearance of the pressure vessel which could indicate possible material fatigue, e.g., deformation of the vessel, difficulty screwing on lids, etc. even when the vessel is cold and not under pressure. All such vessels should be immediately returned to Berghof Products + Instruments GmbH for inspection.

Never attempt to use force to open the vessels. Never use tools to open the vessels!

The pressure vessels are equipped with a rupture disc which produces a spontaneous pressure release upwards through the screw-on tube connections in case of excessive vessel pressure. In some cases, such a spontaneous pressure release may occur after the vessel has been removed from the microwave oven.

Hot gases and vapors may be released from the digestion vessel when it is opened! Always make sure the vent opening on pressure vessels faces away from both yourself and other individuals!!

Only open the digestion vessel under a fume hood or other exhaust system. Particular care is required when working with hydrofluoric acid (HF). Observe all relevant data sheets and safety instructions!

Never use more than one rupture disc per vessel!

**Note:**

Renew the vessels after around 10,000 digestions to maintain reliable operating conditions and to prevent negative influences on your analysis results (e.g. memory effects etc.).

Berghof Products + Instruments GmbH includes its digestion vessels in the warranty coverage. Nevertheless all of the vessels are subject to a certain aging process, which also depends on the type and frequency of the application. Typically the service life is 10,000 digestion processes or at least 3 years.

**Warning ! The unit employs high voltage and generates microwave radiation!**

The **speedwave four** must always be carefully connected to a grounded conductor. Provided the wall outlet used is equipped with a ground connection, the supplied power cord will ensure proper connection. If it is necessary to use an extension cord to connect the system to the power supply, only a three-wire cord with a ground connection may be employed.

The unit should not be set up near any devices which are sensitive to electromagnetic radiation. If necessary, a warning sign or label indicating "Caution, Microwave Emissions" should be applied or attached to the unit. Should there be any suspicion or indication of increased levels of microwave radiation, please immediately inform the Service Department at Berghof Products + Instruments GmbH (Refer to the "Repairs / Customer Service" section for the contact address).

Repair and servicing of the equipment may only be performed by trained personnel.

1.5. Safety and Emissions

In the following situations, the unit must be disconnected from the mains power supply and be locked out to prevent accidental use:

- If the unit evidences visible signs of damage;
- If unit parts or components are found to be loose;
- If the unit fails to operate;
- If the unit is to be stored for extended periods of time under unfavorable conditions (e.g., outdoors, in very moist or humid environments).



Caution

The housing cover may only be removed by authorized trained personnel!
The unit must be disconnected from the mains power supply.

Safety information on the unit

| | | |
|--------------|-------------------|--|
| | GEFAHR! | Vor Öffnen des Gerätes Netzstecker ziehen. |
| | DANGER! | Avant d'ouvrir l'appareil retirez la fiche mâle. |
| | DANGER! | Before opening disconnect mains. |
| | <i>¡PELIGRO!</i> | Retirar el enchufe de red antes de abrir el equipo. |
| HIGH VOLTAGE | | |
| | GEFAHR! | Hochspannung |
| | DANGER! | Haute tension |
| | DANGER! | High voltage |
| | <i>¡PELIGRO!</i> | Alta tensión |
| HIGH VOLTAGE | | |
| | VORSICHT! | Nur Netzkabel mit Erdleiter verwenden. |
| | ATTENTION! | N'utiliser que des câbles de secteur reliés à la terre. |
| | CAUTION! | Use only cable with plug and protective earth. |
| | <i>¡ATENCIÓN!</i> | Utilizar exclusivamente un cable de red con conector de puesta a tierra. |
| HIGH VOLTAGE | | |
| | VORSICHT! | Gefäß steht unter Druck – erst nach Abkühlung vorsichtig öffnen. |
| | ATTENTION! | Le récipient se trouvant sous pression, ne l'ouvrir avec précaution qu'après qu'il ait refroidi. |
| | CAUTION! | Vessel under pressure – open carefully after cooling. |
| | <i>¡ATENCIÓN!</i> | Recipient bajo presión – Abrir cuidadosamente de spués de enfriar. |
| EXPLOSIVE | | |

European Community

This device has been designed and tested in accordance with the following IEC publications:

| | |
|-----------------|--|
| IEC 61010-1: | Safety requirements for electrical equipment for measurement, control, and laboratory use. |
| IEC 60335-2-90: | Particular requirements for commercial microwave ovens. |

CE designation

Products from Berghof Products + Instruments GmbH comply with the guidelines of the VDE and the European Standards. The conformity tests performed by Berghof Products + Instruments GmbH comply with the currently required standards for electrical safety as well as the safety of microwave ovens. All limit values with respect to interference emission and interference protection have been maintained.

This device operates within the limit values set forth in the following standards:

- EN 335-25 (microwave devices);
- DIN EN 61010-1 (safety)
- DIN EN 61326-1 (interference emissions);
- DIN EN 61326-2 (interference resistance).

Conformity declaration

Refer to the Appendix

1.6. Informations on Disposal

European Union

Electrical and electronic products should not be mixed with general household waste. Berghof Products + Instruments GmbH accepts its electrical and electronic instruments from on a free of charge basis for proper treatment, recovery and recycling from their business users. If you wish to discard electrical and electronic products, please contact your local dealer or Berghof Products + Instruments GmbH (info@berghof-instruments.de). They will provide further information.

Disposing of this product correctly will help to protect our environment..

Countries outside the European Union

This regulation is only valid in the European Union

**Note:**

Berghof-Products are not used in private households.

1.7. Warranty / Limitation of Warranty

Limited Warranty

Each product manufactured by Berghof Products + Instruments GmbH is warranted to conform to Berghof Products + Instruments GmbH's applicable specifications on the date of shipment. The warranty period is twelve (12) months after the date of delivery, unless another period is specified. The warranty does not extend to damages due to improper installation, improper maintenance, abuse, accident, negligence, alteration, misuse, ordinary wear and tear, or the like. Claims for replacement of parts caused by ordinary wear and tear are excluded, as are claims for replacement of parts meant to be expended during the operation of the equipment.

Berghof Products + Instruments GmbH also includes its digestion vessels under this warranty.

However, high temperatures $>280^{\circ}\text{C}$ ($>536^{\circ}\text{F}$), such as may briefly occur when exothermic reactions take place can result in irreversible damage to the TFM vessels. Since such scorching cannot always be avoided even by optimal microwave power regulation, the resulting damages are excluded from the warranty! Care must also be taken when handling quartz glass or ceramic inserts as their reliability can be seriously impaired by even minor damage to their surfaces. Therefore, glass and ceramic components are also excluded from this warranty!

Remedies

Under the limited warranty, Berghof Products + Instruments GmbH repairs or replaces any products which Berghof Products + Instruments GmbH determines to be defective and covered by this limited warranty. This is the sole and exclusive remedy. If Berghof Products + Instruments GmbH determines that repair or replacement fails its essential purpose, the purchaser will, at its option, be entitled to a refund of the purchase price for the products in question or a credit therefore.

All warranty claims must be accompanied by a description of the claim, which description must be attached to the equipment claimed to be defective. Claim descriptions must include the claimants name, address, department (if applicable) and telephone number.

The equipment should be returned in its original packaging, to the extent possible. We regret that Berghof Products + Instruments GmbH cannot be held responsible for damage caused during shipping due to improper packaging.

LIMITATION OF WARRANTY

EXCEPT AS EXPRESSLY SET FORTH ABOVE, THERE ARE NO OTHER WARRANTIES HEREUNDER, WHETHER EXPRESSED OR IMPLIED, ARISING BY OPERATION OF LAW OR OTHERWISE, INCLUDING WITHOUT LIMITATION, THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND ANY WARRANTIES ARISING UNDER COURSE OF PERFORMANCE, COURSE OF DEALING OR USAGE OF TRADE.

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2. Device Description

2.1. Basic Unit

The **speedwave** four microwave system is designed for pressure digestion at temperatures up to 230 °C (446 °F) in continuous use (short term 300 °C / 572 °F) and, depending on the type of vessels employed, pressures up to a max. of 100 bar (1450 psi).

This is a top loading microwave made of 1.4301 (SS 304) stainless steel and equipped with a swiveling safety lid, electromechanical locking mechanism and a circular sample chamber for uniform microwave distribution. The oven has a highly chemicals resistant PFA coating protecting it from corrosion. Three over-temperature switches and three micro-switches guarantee the necessary operating safety. The chamber is permanently ventilated by a special fan.

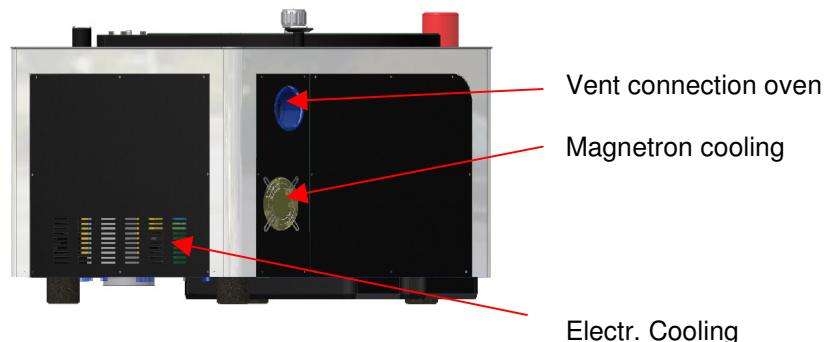
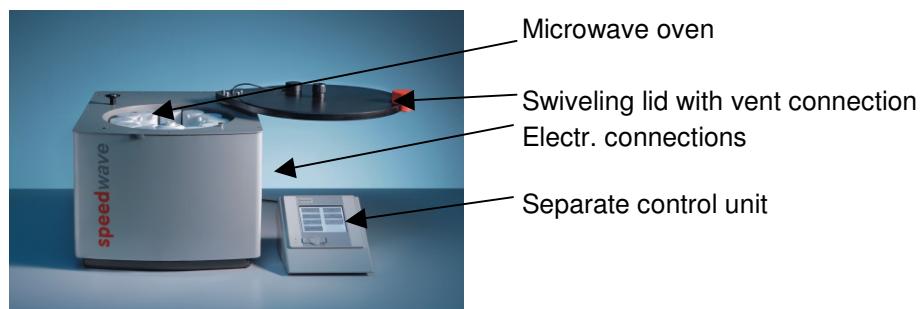
An DIRC thermometer that permits the temperature of the vessel contents to be quickly determined and regulated is integrated in the microwave oven. *The measurement physically determines the temperature radiation emitted by the vessel contents, that is, the digestion solution.* Radiation components emitted by the vessel walls and, in particular, the exterior of the vessel, are completely filtered out.

Optionally the system can be equipped with a contact-free pressure monitoring system for either individual or for all vessels. This records the internal vessel pressure. If a vessel is approaching its maximum pressure, the system automatically switches to a pressure-controlled mode for the microwave output.

An unpulsed regulated 2.45 GHz magnetron provides up to 1,450 W of microwave power. The microwave is controlled by a separate controller with touch-screen. After entering the desired temperature profile, the microwave output is infinitely varied in accordance with the measured sample temperatures. The target and actual temperatures of all samples are displayed on the screen in real time and saved to memory.

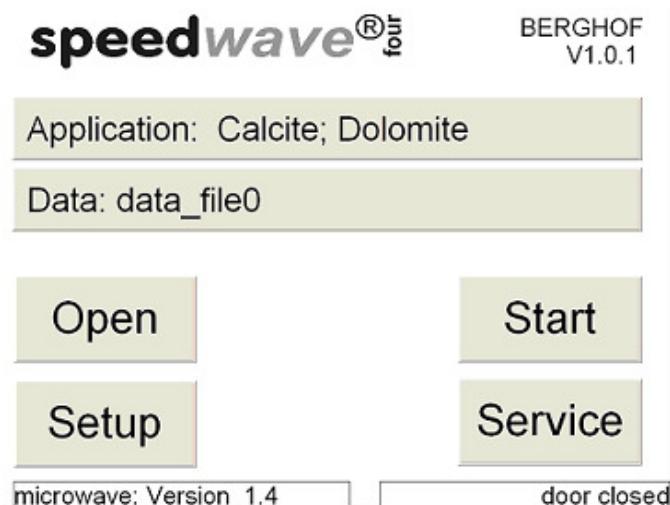
Connections

As the following figures illustrate, the **speedwave** four is equipped with various connection options.



Controller

A separate control unit with power PC 5200, 5.7" touch screen and graphics display is used to control the microwave oven. The english, german or french language software is preinstalled at the factory.

Main window**Key functions**

| Button: | Function |
|--------------------|---|
| Application | Function for selecting or creating an application. The active application is displayed (in the illustration above "Calcite; Dolomite"). |
| Data | Function for viewing stored digestion data. The most recently used file is displayed. (in the illustration above "data_file0") |
| Open | Unlock door (only possible if magnetron is off) |
| Setup | Setup menu Access with 4-digit access code only. (factory setting 4321) |
| Start | Start the microwave |
| Service | Service menu: Access for authorized service technicians only |

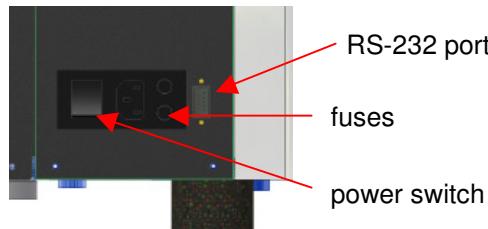
The version number of the control software is displayed in the header of the main menu and in the footer the version number of the firmware of the **speedwave** four and the status of the swivel lid.

**Connections
(basic instrument)**

The mains power switch is located on the right-hand side of the unit.

The switch is illuminated while it is on.

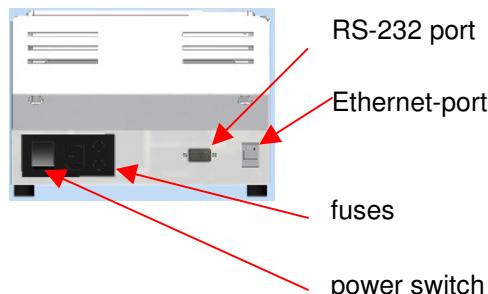
Next to this are the fuses and the RS-232 port for connecting with separate control unit.

**Connections
(control unit)**

The mains power switch is located on the back of the unit.

The switch is illuminated while it is on.

Next to this are the fuses and the ports for connecting with the basic instrument and ethernet.



2.2. Temperature Monitoring

The **speedwave** four is equipped with a temperature monitoring system. This system determines the temperature inside the pressure vessels by measuring the direct infrared radiation emitted by the sample. This allows the temperatures of all samples to be determined. This information is forwarded to the power control module which uses the highest measured temperature to regulate the oven power. Continuous adjustment of the magnetron output allows the temperature to be regulated on the basis of all vessel contents.

For measurement instrumentation reasons, only temperatures above 50°C (122°F) can be displayed. Temperatures below 50°C (122°F) are indicated on the display by "low".

2.3. Pressure Monitoring (Option)

Optionally, the **speedwave** four can be equipped with a pressure monitoring system. To achieve this, the pressure in the vessels is determined by using polarized light to measure any change in the photoelastic behavior of a glass ring in the vessel lid. This allows the internal pressures of all or of individual vessels to be detected. This information is conveyed to the output control module, which can use the highest measured pressure to regulate the output. By continuously adjusting the magnetron output pressure regulation referenced to individual vessels can be achieved while preventing other over-pressure safety devices (rupture discs) from being activated.

2.4. Pressure Vessels and Rotor Systems

All Berghof pressure vessels are manually operated. A rupture disc placed in the vessel lid limits the interior pressure of all vessel types to the maximum permissible value for the individual type. For all vessels except DAP-40+ acid vapors that escape when the rupture disc activates are guided to a collection system integrated in the rotor. Thereby the vapors are vented or suctioned off through the PFA tube connected to the swiveling lid.

DAP-40+

DAP-40+ vessels are made entirely of TFM®. Aside from chemical resistance to all mineral acids including hydrofluoric acid, this ensures a high level of mechanical strength, even at high digestion temperatures.



- 24 pressure vessels made of TFM
- Rotor

DAP-30+/-60+/-100+

DAP-30+, DAP-60+ and DAP-100+ vessels are made entirely of TFM®. Aside from chemical resistance to all mineral acids including hydrofluoric acid, this ensures a high level of mechanical strength, even at high digestion temperatures.



- 12 pressure vessels made of TFM
- Rotor
- Gas collection system

DAK-100/4

DAK-100/4 vessels are made of a TFM™-pressure vessel with cap. Beside this, this vessel consists of a ceramic pressure jacket and a TFM™-insert.



- 8 pressure vessels made of TFM™
- Rotor
- Gas collection system

DAQ-20H

For digestion of small sample weights quartz inserts may be placed into pressure vessels DAP-60+ or DAP-100+.



- Quartz vessel
- TFM-cap

DAC-17

The DAC-17 are special high pressure inserts intended for digestion of small and hard-to-digest samples.



- TFM-insert
- Ceramic pressure jacket
- DAP-100+ vessel

MT-System

For the digestion of small sample quantities or several samples at the same time in a single DAP-100+ or DAK-100/4 pressure vessel it is possible to use these special vessels.



- PFA-Insert

2.5. Technical Specifications

Technical specifications for the **speedwave four**

Microwave oven

| | |
|---------------------|----------------------|
| Power supply | 230 V |
| Frequency | 50 / 60 Hz |
| Current | 15 A |
| Power consumption | 2000 W |
| Fuses | 2 x 15 AT, two-phase |
| Magnetron frequency | 2450 MHz |
| Microwave power | 1,450 W |

Exterior dimensions (W x D x H) 640 x 570 x 430 mm
(25.2 x 22.4 x 16.9 inches)

| | |
|--------------------------|---|
| Interior dimensions (ID) | 360 mm (14.2 inches) |
| Weight (approx.) | 65 kg (143 lb) without vessels |
| Noise level | < 60 dB |
| DIRC temperature range | 50 °C – 300 °C (122 - 572 °F) |
| Pressure sensor range | 0 – 150 bar (2180 psi) Display 0 - 100 bar (1450psi) |

Controls

| | |
|------------------------------|--------------------------------|
| Power PC 5200 | |
| 5,7" touch-screen, monochrom | |
| Program memory | 200 programs, 25 preprogrammed |
| Data file memory | min. 500 data files |
| Display | 320 x 240 pixel |
| Interface | RS-232, Ethernet, USB |

Pressure vessels

Material

TFM®, PEEK, quartz, aluminum oxide

| | Volume | Max. pressure | Max. temperature | max. sample weight (organic) | Min. fill volume (acid) |
|-----------|--------|-------------------|------------------|------------------------------|-------------------------|
| DAP-40+ | 40ml | 40 bar (580psi) | 230 °C (446 °F) | < 300 mg | > 5ml |
| DAP-30+ | 30 ml | 80 bar (1160psi) | 230 °C (446 °F) | < 300 mg | > 5ml |
| DAP-60+ | 60 ml | 40 bar # (580psi) | 230 °C (446 °F) | < 500 mg | > 5ml |
| DAP-100+ | 100 ml | 40 bar * (580psi) | 230 °C (446 °F) | < 500 mg | > 5ml |
| DAK-100/4 | 100 ml | 100 bar (1450psi) | 230 °C (446 °F) | < 1000 mg | > 5ml |
| DAQ-20 | 20 ml | 100 bar (1450psi) | 230 °C (446 °F) | < 300 mg | > 5ml |
| DAC-17 | 17 ml | 130 bar (1885psi) | 300 °C (572 °F) | < 200 mg | > 5ml |

*25bar above 200 °C

50bar with special rupture discs (not enclosed in standard delivery)

Short - term (max. 15 min.) heating to 260 °C (500 °F) is possible with all vessels.

Overpressure protection: Rupture disc for all pressure vessels

2.6. Safety Equipment

Swiveling lid

The system is equipped with a solid, PFA-coated, stainless steel housing with a swiveling safety lid for maximum user safety. The electronic lid-locking mechanism can only be opened by means of the software control. In addition, 3 interlock switches are installed which shut the microwave off if the lid is opened by force during microwave operation.



Warning !

The unit emits microwave radiation!

Never operate the microwave oven if the swiveling lid or the related lock mechanism have been damaged. Contact your local, authorized dealer or Berghof Products + Instruments GmbH to obtain the required service (Refer to the "Repairs / Customer Service" section for contact addresses).

Rupture discs

All vessels are equipped with a rupture disc which produces a spontaneous pressure release upwards through the screw-on tube connections in case of excessive vessel pressure. In some cases, such a spontaneous pressure release may occur after the vessel has been removed from the microwave oven.



Warning !

Rupture discs as overpressure protection!

Use only original Berghof rupture discs and protective cover sheets. These can be obtained from your local, authorized dealer or Berghof Products + Instruments GmbH (Refer to the "Repairs / Customer Service" section for contact addresses).

Never use more than one rupture disc per vessel!

Gas exhaust

All pressure vessels are equipped with a sealed connection to a gas collection system which, in turn, must be connected to an exhaust system via a PFA vent tube. The PFA tube is connected to the screw-on connection located in the center of the top of the microwave. Any hot acid vapors released when the rupture disc activates are safely removed through this PFA vent tube.



Warning !

Hot acid vapors may be released.

The supplied vent tubes must therefore always be properly connected and attached to an exhaust system.

Make sure the PFA tube is securely attached so that it cannot pop off its connection fitting in case of a percussive pressure burst as occurs when a rupture disc activates.

Temperature control

The system is equipped with a temperature control of all sample temperatures as described in the section, "Temperature Monitoring". An emergency shut-off occurs in case of a rupture disc break.

Pressure control

Optionally, the system can be equipped with a pressure monitoring system for all internal vessel pressures as described in the 'Pressure Control' section.

Over-temperature protection

For safety reasons, the microwave automatically switches itself off in case the magnetron, the microwave oven, or the high voltage transformer overheats.

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3. Setup and Commissioning

3.1. Standard Delivery

speedwave four microwave oven

with built-in DIRC temperature sensor, OPC optical pressure control
and separate control unit (part no. 5304000)

- 1x **speedwave four** control unit (part no. 5304800)
- 1x power cord (part no. 50003117)
- 1x power cord (part no. 500003107)
- 1x RS-232 cable (part no. 5303195)
- 1x PE-corrugated hose Ø65mm; 2,5m (part no. 5304044)
- 1x **speedwave four** manual german/english
(part no. 5304091/ 5304092)

a set (24) of DAP-40+ pressure digestion vessels (40ml, 40bar/ 580psi) (part no. 5303480)

- 24x DAP-40+ pressure vessels (part no. 5303270)
- 1x **speedwave four** rotor for DAP (part no. 5303449)
- 1x forming tool (part no. 5303437)
- 1x DAP-40 lid set, 10 each (part no. 5303446)
- 1x rupture disc set, 25 each (part no. 5303445)

and DAP-40+ cap for pressure control (part no. 5303790)

- 1x cap for DAP-40+ vessels with pressure sensor (part no. 5303790)

or a set (12) of DAP-30+ pressure digestion vessels (30ml, 80bar/ 1160psi) (part no. 5303680)

- 12x DAP-30+ pressure vessels (part no. 5303605)
- 1x **speedwave four** rotor for DAP (part no. 5303530)
- 1x vent tube for DAP (part no. 5303227)
- 1x forming tool (part no. 5709025)
- 1x DAP-30 lid set, 10 each (part no. 5709024)
- 1x rupture disc set, 25 each (part no. 5014616)
- 1x lip seal ring (part no. 5302962)

or a set (12) of DAP-60+ pressure digestion vessels (60ml, 40bar/ 580psi) (part no. 5303570)

- 12x DAP-60+ pressure vessels (part no. 5303603)
- 1x **speedwave four** rotor for DAP (part no. 5303530)
- 1x vent tube for DAP (part no. 5303227)
- 1x forming tool (part no. 5014612)
- 1x DAP-60 lid set, 5 each (part no. 5014617)
- 1x rupture disc set, 25 each (part no. 5014616)
- 1x lip seal ring (part no. 5302962)

or a set (12) of DAP-100+ pressure digestion vessels (100ml, 40bar/ 580psi) (part no. 5303670)

- 12x DAP-100+ pressure vessels (part no. 5303672)
- 1x **speedwave four** rotor for DAP (part no. 5303530)
- 1x vent tube for DAP (part no. 5303227)
- 1x forming system (part no. 5303245)
- 1x DAP-80/100 lid set, 5 each (part no. 5300005)
- 1x rupture disc set, 25 each (part no. 5014616)
- 1x lip seal ring (part no. 5302962)

and a set (12) DAP cap without pressure sensor (part no. 5303540)

- 12x locking caps for DAP vessels without pressure sensor (part no. 5303540)

or a set (12) DAP cap for pressure control (part no. 5303590)

- 12x caps for DAP vessels with pressure sensor (part no. 5303580)

or a set (8) DAK-100/4 pressure digestion vessels (100ml, 100bar/1450psi) (part no. 5304980)

- 8x DAK-100/4 pressure vessels (part no. 5303279)
- 1x **speedwave four** rotor for DAK-100/4 (part no. 5304710)
- 1x vent tube for DAK (part no. 5303228)
- 1x forming station (part no. 5303245)
- 1x DAK lid set, 5 each (part no. 5302808)
- 1x rupture disc set, 5 each (part no. 5308030)
- 1x Opening station (part no. 5303625)
- 1x lip seal ring (part no. 5302962)

and a set (8) DAK-100/4 cap without pressure sensor (part no. 5304730)

- 8x locking caps for DAK-100/4 vessels without pressure sensor (part no. 5304740)

or a set (8) DAK-100/4 cap for pressure control (part no. 5304770)

- 8x caps for DAK-100/4 vessels with pressure sensor (part no. 5304760)

and a set (12) supplement DAC-17A (17ml, 130bar/1885psi) (part no. 5303340)

- 12x DAC-17 inserts complete (part no. 5303280)

or a set (12) supplement DAQ-20H (20ml, 100bar/1450psi) (part no. 5014412)

- 12x DAQ-10H quartz inserts complete (part no. 5014401)
- 1x forming tool (part no. 5014612)

or a set (24) multi tube system (10ml, 100bar/1450psi) (part no. 5308150)

- 24x MT-inserts made of PFA (part no. 5308054)
- 1x MT tube lifter (part no. 5308052)
- 1x MT rack (part no. 5308055)

Options:**Evaporating set for DAP vessels (part no. 5303690)**

- 12x lids for DAP vessels (part no. 5303226)
- 3x PP gas scrubber bottles (part no. 5005263)
- 2kg (4.4lb) marble granulate (part no. 5014622)
- 1x condenser, with lid (part no. 5302650)
- 11x blind plugs (part no. 5302817)
- 1x scrubber bottle screw-on lid (part no. 5302054)
- 2x scrubber bottle screw-on lids (part no. 5302055)
- 1x evaporating set vent tube (part no. 5302966)
- 1x drop collector (part no. 5303347)

Evaporating set for DAC vessels (part no. 5303950)

- 8x lids for DAC vessels (part no. 5302825)
- 3x PP gas scrubber bottles (part no. 5005263)
- 2kg (4.4lb) marble granulate (part no. 5014622)
- 1x condenser, with lid (part no. 5302650)
- 7x blind plugs (part no. 5302817)
- 1x scrubber bottle screw-on lid (part no. 5302054)
- 2x scrubber bottle screw-on lids (part no. 5302055)
- 1x evaporating set vent tube (part no. 5302966)
- 1x drop collector (part no. 5303348)

Forming system 6-fold for DAP-60+ (part no. 5303385)**Forming system 6-fold for DAP-100+ (part no. 5303275)****Forming system 6-fold for DAK-100/4 (part no. 5303386)****Weighing cup 2,0 ml, Set of 12 pcs. (part no. 5303612)**

- 12x weighing cup 2ml (part no. 5303611)

Weighing cup 2,5 ml, Set of 12 pcs. (part no. 5303614)

- 12x weighing cup 2.5ml (part no. 5303613)

**Stainless steel rupture disc for DAP-60+, 50bar Set of 20 pcs.
(part no. 5303740)****TFM-lid/rupture disc for DAP-60+, Set of 5 pcs. (part no. 5046180)****TFM-lid/rupture disc for DAP-100+, Set of 5 pcs. (part no. 5046170)**

3.2. Standard Delivery Start-up Packages

Start-up Package **speedwave four**

with DIRC Temperature control and OPC Optical Pressure Control
for Routine Analysis of a wide range of sample types
and avarage sample throughput. (part no. 5304910)

- 1x **speedwave four** (part no. 5304000)
- 1x Turntable with DAP-60+ Pressure Vessels (part no. 5303570)
- 12x Closure caps for DAP-vessels without pressure control (part no. 5303540)
- 1x Closure caps for DAP-vessels with pressure control (part no. 5303580)

Start-up Package **speedwave four**

with DIRC Temperature control and OPC Optical Pressure Control
for Routine Analysis of a wide range of sample types
and avarage sample throughput. (part no. 5304920)

- 1x **speedwave four** (part no. 5304000)
- 1x Turntable with DAP-60+ Pressure Vessels (part no. 5303570)
- 12x Closure caps for DAP-vessels with pressure control (part no. 5303590)

Start-up Package **speedwave four**

with DIRC Temperature control and OPC Optical Pressure Control
for Routine Analysis of a wide range of sample types
and high sample throughput. (part no. 5304930)

- 1x **speedwave four** (part no. 5304000)
- 1x Turntable with DAP-40+ Pressure Vessels (part no. 5303480)
- 1x Closure caps for DAP-40+ vessels with pressure control (part no. 5303790)

Start-up Package **speedwave four**

with DIRC Temperature control and OPC Optical Pressure Control
for Routine Analysis of a wide range of sample types
with high pressure vessels. (part no. 5304940)

- 1x **speedwave four** (part no. 5304000)
- 1x Turntable with DAK-10/4+ Pressure Vessels (part no. 5304980)
- 8x Closure caps for DAK-100/4 vessels without pressure control (part no. 5304730)
- 1x Closure caps for DAK-100/4 vessels with pressure control (part no. 5304760)

Start-up Package **speedwave four**

with DIRC Temperature control and OPC Optical Pressure Control
for Routine Analysis of a wide range of sample types
with high pressure vessels. (part no. 5304950)

- 1x **speedwave four** (part no. 5304000)
- 1x Turntable with DAK-10/4+ Pressure Vessels (part no. 5304980)
- 8x Closure caps for DAK-100/4 vessels with pressure control (part no. 5304770)

3.3. Setup and Commissioning

3.3.1. Ambient Conditions

The setup location must meet the following requirements:

| | |
|------------------------|--|
| Ambient temperature: | +10 °C (50 °F) to +35 °C (93 °F) In addition, the temperature should lie between 40 °C (-40 °F) and +70 °C (158 °F) during shipping and storage |
| Max. rel. humidity: | 85% |
| Space requirements: | Approx. 80 x 100 x 90cm (DxWxH) approx. 31.5 x 39.4 x 35.4 inches (DxWxH) |
| Load bearing capacity: | At least 65 kg (143 lb) |
| Electrical connection: | 230V; 50/ 60Hz |

Make sure the vent opening on the back and left side of the unit are not covered. The unit requires at least 15 cm of clearance on the back and left side.

The PFA tube inserted through the top of the oven should be vented to the outdoors or be connected to an exhaust system.

The oven must not be set up in wet conditions (it is not resistant to water sprays) and not under the extraction hood / exhaust (increased risk of corrosion). We recommend setting the unit up next to the extraction hood / exhaust in order to lead the vent hoses to this extraction hood / exhaust.

3.3.2. Unpacking / Inspection

Open the shipping packaging and carefully remove it. Please save all packaging in order to be able to return the unit to the manufacturer in its original packaging, should service be required.

Two individuals should remove the microwave system from its packaging and place it on a lab bench. Also remove all other components and accessories and inspect the delivery to make sure it is complete.

Inspect the system for shipping damage such as cracks, scratches, dents, etc.



Warning !

Visible damage!

For safety reasons, never operate the unit if it exhibits visible signs of damage. Contact your local, authorized dealer or Berghof Products + Instruments GmbH to obtain the required service (Refer to the "Repairs / Customer Service" section for contact addresses).



Note:

Should any components be missing or damages be detected, contact your local, authorized dealer or Berghof Products + Instruments GmbH directly (Refer to the "Repairs / Customer Service" section for contact addresses).

3.3.3. Installation



DANGER ! The unit employs high voltage and generates microwave radiation!

The **speedwave** must always be carefully connected to a grounded conductor. Provided the wall outlet used is equipped with a ground connection, the supplied power cord will ensure proper connection. If it is necessary to use an extension cord to connect the system to the power supply, only a three-wire cord with a ground connection may be employed.

The unit should not be set up near any devices which are sensitive to electromagnetic radiation. If necessary, a warning sign or label indicating "Caution, Microwave Emissions" should be applied or attached to the unit. Should there be any suspicion or indication of increased levels of microwave radiation, please immediately inform the Service Department at Berghof Products + Instruments GmbH (Refer to the "Repairs / Customer Service" section for contact addresses).

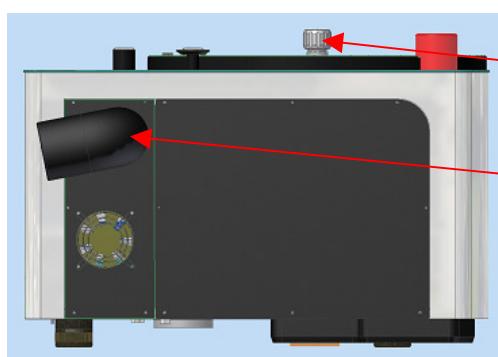
Repair and servicing of the equipment may only be performed by trained personnel.

Positioning

Position the system on the intended work surface. Make sure the vent opening on the left side of the unit is not covered (at least 15cm (5.9inch) clearance). A clearance of at least 50 cm (19.7") that opens towards the front of the unit must be available above the oven. The work surface must be able to support the weight of the oven (approx. 65 kg; 143lb) and must have a surface area of approx. 60 x 100 cm (23,6 x 39,4 inch; LxW).

Exhaust

It is possible to feed or suck off acid fumes directly from the collecting vessel or pressure vessels to an air extraction system via the PFA hose, which can be connected through the lid from above, (e.g. by means of a membrane or water-jet suction pump with an upstream wash bottle). In addition to this the oven chamber is permanently sucked off and the gases must be conveyed to the extraction system via the PE corrugated tube supplied.



Connection PFA exhaust air extraction tube (ø 10 mm)

Connection PFA exhaust air extraction tube (ø 62 mm)



Warning ! Hot acid vapors may be released.

The supplied vent tubes must therefore always be properly connected and attached to an exhaust system.

Make sure the PFA tube is securely attached so that it cannot pop off its connection fitting in case of a percussive pressure burst as occurs when a rupture disc activates



Connections

Note:

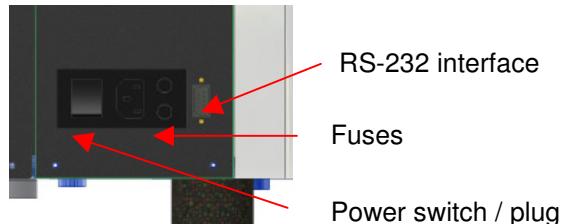
Users are responsible for assuring that appropriate ventilation of toxic gases is assured. Make sure that all ventilation procedures conform to applicable laws.

Power switch (Basic device)

The power switch is located on the right-hand side of the device

The switch is illuminated when switched on.

The fuses and the RS-232 connection for the control unit are next to it.



RS-232 interface

Fuses

Power switch / plug

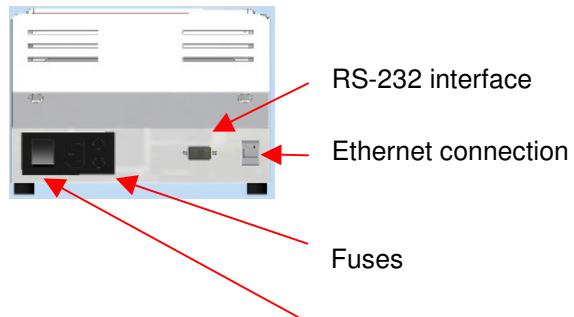
Power switch (control unit)

The power switch is located at the rear of the device

The switch is illuminated when switched on.

The fuses are located next to it.

The RS-232 connection serves as the connection to the basic device and the Ethernet jack for connecting up to a network.



RS-232 interface

Ethernet connection

Fuses

Power switch / plug

Turntable installation

Switch the control unit and then the device on at mains power switch and wait until the main menu is set up on the screen. This may take a few seconds while the screen remains dark.

Open the lid by pressing the open key on the keypad. A clearly audible clicking is heard and unlocking is indicated on the screen. Then open the lid with the red handle. The lid then swings to the right to its end stop. After 10 seconds the lid is automatically locked again. In this case, again press open.

The rotor for the pressure vessels is preassembled on delivery. Remove the pressure vessels and insert the empty rotor into the microwave oven. By gently turning the rotor on the axis, find the position at which the rotor again engages downwards. The rotor is now correctly positioned in the microwave oven.

Accessories

The opening station for DAk-100/4 pressure vessels can be secured in an exhaust hood / vent unit by means of the adhesives strips on its underside.

Setup

Enter the setup window by pressing the **Setup** key. This area is password-protected. The default password is 4321.

The following parameters may be changed therein:

| Parameter | Description | Factory settings | min. value | max. value |
|------------------------|--|------------------|------------|------------|
| T max set | Max. allowed temp. in programs | 300 °C | 0 °C | 300 °C |
| T min set | Min. allowed temp. in programs | 50 °C | 0 °C | 300 °C |
| P max set | Max. allowed pressure in programs | 100 bar | 0 bar | 130 bar |
| p min set | Min. allowed pressure in programs | 0 bar | 0 bar | 130 bar |
| Power max set | Max. allowed power in programs | 100 % | 0 % | 100 % |
| power min set | Min. allowed power in programs | 0 % | 0 % | 100 % |
| Start with application | Application, which is to be active after the device is switched on | 1 | | |
| User password | The user can input a max. 4-digit combination of numbers as a password. This can be used as an alternative to the default combination "4321" | 0 | 0 | 9999 |
| Pressure on/off | The OPC pressure measurement can generally be activated or deactivated | on | | |
| Alarm time | Max. runtime of a temperature program | 40 min. | 0 min. | 120 min |

| | | |
|------------------------|----|-----|
| T max set | 1 | 300 |
| T min set | 2 | 50 |
| p max set | 3 | 130 |
| p min set | 4 | 0 |
| power max set | 5 | 100 |
| power min set | 6 | 0 |
| start with application | 7 | 1 |
| user password | 8 | 0 |
| pressure on/off | 9 | 1 |
| alarm time | 10 | 40 |

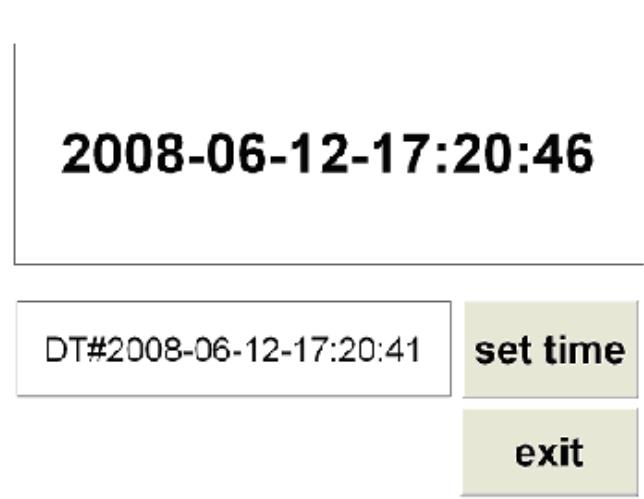
OK
next
set time

on

deutsch
english
francaise
espanol
more

The software can be changed to the relevant language by pressing a language button.

The date and time can be set by selecting the **set time** function. Time and date have to be inserted precisely in the format below (DT#2008-06-12-17:20:41).



The system is now ready for use.

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4. Hardware and Software Operation

4.1. Method Preparation

4.1.1. Information Regarding Digestion

The applied microwave energy causes the sample material to heat rapidly. The speed of this heating process depends on the total volume of liquid in the oven as well as on the amount of microwave radiation applied (power). The **speedwave** four is controlled by continuously adjusting the microwave power. Sample temperature and sample pressure in each vessel are simultaneously acquired in a contactless process during every rotation of the sample turntable, and the microwave power level is adjusted accordingly. In addition, microwave power is also controlled on the basis of the number of samples actually present in the turntable. This graduated regulation concept leads to reproducible heating curves and therefore to reproducible results.

Heating the acid mixture results in the creation of vapor pressure. The degree of this vapor pressure depends greatly on the temperature. All digestion vessels have a maximum permissible pressure. If this maximum pressure is exceeded, the rupture disc in the pressure vessel activates, providing a rapid pressure release into the collection vessel.

In addition to the vapor pressure, reaction gases (primarily carbon dioxide generated by samples containing carbon) also produce pressure. This pressure is therefore dependent on the sample amount, the vessel volume, as well as the carbon content of the sample.

Together with the applied microwave radiation, digestion of organic substances also releases reaction heat. These types of reactions frequently begin in the temperature range between 130 - 150 °C (266 - 302 °F). We therefore recommend holding the samples at this temperature for some time (3-5 minutes), in order to allow this reaction heat to subside somewhat. The temperature should then be increased to the desired maximum in a second stage in order to obtain optimum digestion quality.

**Caution****Reaching the maximum pressure!**

Please note that the reaction pressure is only reached during the course of the reaction, in other words, several minutes after the maximum temperature has been reached. Therefore, an activation of the rupture discs may be anticipated even after the temperature has reached a constant level.

Optionally the **speedwave** four can be equipped with pressure monitoring. With this option the internal vessel pressure is determined and, when the preset maximum pressure is reached, the unit automatically switches to a pressure-controlled mode. In this mode the microwave output is controlled so that the internal pressure of the vessel does not exceed the maximum pressure.

**Caution****Rupture disc corrosion!**

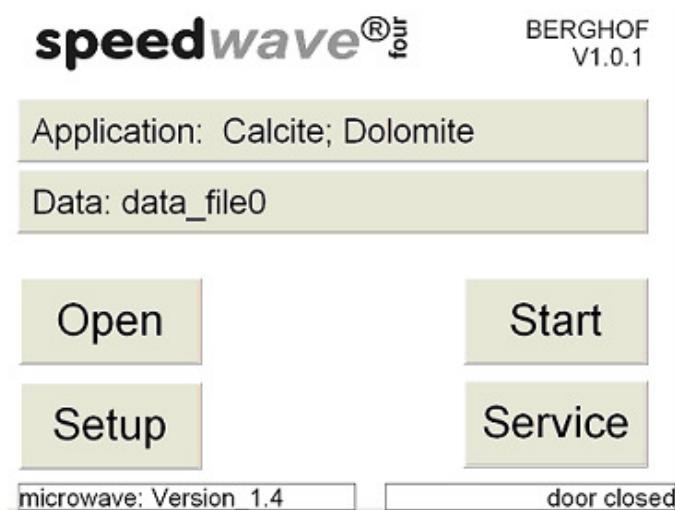
Depending on the acid being employed and the digestion parameters, the aluminum rupture discs are subject to more-or-less extreme wear. Replace the discs regularly (after approximately every 20 digestion procedures) to prevent the discs from rupturing prematurely.

4.1.2. Controller

The control unit is operated via a touch-screen. In order to trigger a function, briefly press on the representative symbol on the screen. In the following text the key fields of the touch-screen are shown in a frame, e.g., **Application**. Pressing the **ok** or **esc** key always takes you from a submenu to the next higher menu

Main window

Switch the control unit and then the device on at mains power switch and wait until the main menu is set up on the screen. This may take a few seconds (approx. 15 sec.) while the screen remains dark.



Operation

If a key is selected which request insertion of text or figures a keypad is displayed.



Key functions

| key: | Function |
|--------------------|---|
| Application | Function for selecting or modifying a stored application. Active application is displayed. (in example above "Calcite; Dolomite") |
| Data | Function to review stored digestion process data. Last data file is displayed. (in example above "data_file0") |
| Start | Start of microwave |
| Service | Service area Access for authorized service technicians only. |
| Open | release the electronic lid locking (only possible when microwave is stopped) |
| Setup | Setup. Access with 4-digit code (factory setting 4321) |

4.1.3. Modifying Application

The operator can select from a total of 200 applications, 25 of which are pre-installed.

After accessing the **application** function initially a selection of maximally 12 applications is displayed which the user can compile to form a "User Library". Furthermore, 3 standard applications are stored: pressure adjustment, power test and function test.

| | | | |
|-------------------------|-------------------|----------------------|-----------|
| selected application: 0 | add | modify | OK |
| 1: Calcite; Dolomite | 7: empty | | |
| 2: Feldspar | 8: empty | | |
| 3: empty | 9: empty | | |
| 4: empty | 10: empty | | |
| 5: empty | 11: empty | | |
| 6: empty | 12: empty | | |
| pressure adjust | power test | function test | |

To modify an application a method is selected and the detailed data **modified** using **modify**. With **"add"** all available applications are displayed, one of which can also be selected.

| application | |
|-------------|----------------------------|
| 11 | Food (high fat) |
| 12 | Glass, Quartz |
| 13 | Limestone |
| 14 | Oil, Lubricant |
| 15 | Plastic,PE, RoHs |
| 16 | Plastic, Waste DIN 22022-1 |
| 17 | Soil ISO 11466, EN 13346 |
| 18 | Soil EPA 3051 |
| 19 | Soil, Sediment EPA 3052 |
| 20 | Tissue, Blood |

Select a application and the wwindow for programming and modifiing applications is opened.

A program always comprises five steps, containing the parameters:

Select as your application

With this it is possible to allocate disk space for the application in the "User Library". Permissible range: 0 – 12

It must be borne in mind that applications can only be allocated to empty fields in the Library. If an application is positioned in a disk space which is already occupied, the old application must first be deleted by using "0" before the new method and be stored.

Temperature (°C)

Setpoint temperature, in °C (Refer to the "Appendix" for conversion)
Permissible range: 50-300 °C

Pressure (bar)

Max. pressure in bar (Refer to the "Appendix" for conversion)
Permissible range: 0-100 bar

Time (min)

Time in min. for which the setpoint temperature shall be kept constant
Permissible range: 0-59 min.

Slope (min)

Ramp time of the program step, in min.
Permissible range: 0-59 min.

Power (%)

Max. power in % which shall be applied in this step.
Permissible range: 0-100%

Vessel

Number of type of vessel, see table on right hand side

Mag temp.

Max. allowed magnetron temperature
Permissible range: 0 -120 °C
Typical range: 80 – 90 °C
Values <20 °C are only used for evaporation programs, refer to 'Appendix'

Total time

Total run time in min.
The maximum permitted runtime of a program is defined in Setup.

PI Parameter

The PI parameters define the system's temperature regulation characteristics based on the following relationship:

$$\text{Power [%]} = (\text{Prop} + \text{I}) * * \text{P}_{\text{limit}}$$

$$\text{where} \quad \text{Prop} = \Delta T * \text{P-band}$$

$$\text{I} = \text{Int} + \Delta T / \text{Int}$$

$$\Delta T = T_{\text{ soll}} - T_{\text{ ist}}$$

P-band

Proportional amplification of the PI regulation

Int

Integral share of the PI regulation

P_{limit}

Means power % of corresponding program step

| Calcite; Dolomite | | | | | | DAP30 |
|--|-------------|----------|------------|--------|-------|--------|
| select as your application (0...12): 1 | | | | | | DAP40 |
| | temperature | pressure | ramp | time | power | DAP60 |
| 1 | 155 | 50 | 2 | 15 | 90 | DAP80 |
| 2 | 200 | 50 | 10 | 30 | 90 | DAP100 |
| 3 | 50 | 0 | 1 | 15 | 0 | DAC17 |
| 4 | 50 | 0 | 1 | 1 | 0 | DAQ20 |
| 5 | 50 | 0 | 1 | 1 | 0 | DAK100 |
| | int | p-band | total time | vessel | magT | DAS100 |
| | 20 | 20 | 77 | 3 | 120 | DAP-70 |
| save + exit exit | | | | | | |

Exit this function by pressing **exit** or **save + exit**.
 25 programs have been preinstalled.

| Program-No. | Description |
|-------------|-------------------------------|
| 1 | Calcite, Dolomite |
| 2 | Cleaning, Vessel conditioning |
| 3 | Coal, DIN 22022-1 |
| 4 | Complexation H3BO3 |
| 5 | Evaporation |
| 6 | Feed |
| 7 | Feldspar |
| 8 | Filter, glass fiber |
| 9 | Fly Ash, DIN EN 14385 |
| 10 | Food (no/low fat) |
| 11 | Food (High fat) |
| 12 | Glass, Quartz |
| 13 | Limestone |
| 14 | Oil, Lubricant |
| 15 | Plastic, PE, ROHs |
| 16 | Plastic, Waste DIN 22022-1 |
| 17 | Soil ISO 11466, EN 13346 |
| 18 | Soil EPA 3051 |
| 19 | Soil, Sediment EPA 3052 |
| 20 | Tissue, Blood |
| 21 | Vegetables, Leaves |
| 22 | Vegetable Oil |
| 23 | Water DIN EN 1189, ISO 6878 |
| 24 | Water Aqua Regia |
| 25 | Water EPA 3015 |

**Note:**

Program 5 **evaporation** is used for evaporation of acid solutions only! Times may be changed only and magT must be set to <20 °C.

4.1.4. Developing a New Application

Digestion of new sample material, that is, of samples for which you have no previous experience, requires a special, systematic procedure. We recommend the following process when developing such an application:

- Check the “*Appendix*” to determine whether the application list already contains work instructions for the sample material in question or for a similar material then, if necessary, request a copy of the original process instructions from your local, authorized dealer or from Berghof Products + Instruments GmbH.
- Should you not be able to find your sample material, search through the relevant technical literature for a corresponding process instruction. You can also request assistance from your local, authorized dealer or from Berghof Products + Instruments GmbH.
- For safety reasons, initially reduce the specified sample amount by 30-50 %, while still using the specified acid quantity and digesting with the defined temperature program.
- Optimize the acid mixture and the temperature profile until you obtain a clear solution.
- In the final step you can gradually increase the sample amount until the higher pressure causes the rupture disc to activate. The maximum sample quantity to be used should be approx. 30 % of this amount.
If the pressure control system is installed the maximum sample quantity may also be estimated from the measured pressures in the digestion vessels.

**Note:**

When digesting unknown sample materials (e.g., when developing methods) we recommend digesting only single samples in the **speedwave** four.

The single sample is automatically positioned directly in front of the sensors and rotor rotation is stopped. This simplifies continuous temperature and pressure monitoring for this vessel.

4.2. Performing a Digestion Procedure



Warning ! Always wear eye protection!

Always wear safety glasses/goggles and protective gloves during work which may involve contact with chemicals, that is, when working with acids, pressure vessels, during cleaning, etc.!



DANGER ! Pressure vessels!

Use only digestion vessels and spare parts authorized by Berghof Products + Instruments GmbH for use with the **speedwave**. These can be obtained either from your local dealer or directly from Berghof Products + Instruments GmbH (Refer to the "Repairs / Customer Service" section for contact addresses).

Always wear safety glasses/goggles and protective gloves when working with the pressure vessels!

Note any changes in the appearance of the pressure vessel which could indicate possible material fatigue, e.g., deformation of the vessel, difficulty screwing on lids, etc. even when the vessel is cold and not under pressure. All such vessels should be immediately returned to Berghof Products + Instruments GmbH for inspection.

Never attempt to use force to open the vessels. Never use tools to open the vessels!

The pressure vessels are equipped with a rupture disc which produces a spontaneous pressure release upwards through the screw-on tube connections in case of excessive vessel pressure. In some cases, such a spontaneous pressure release may occur after the vessel has been removed from the microwave oven.

Hot gases and vapors may be released from the digestion vessel when it is opened! Always make sure the vent opening on pressure vessels faces away from both yourself and other individuals!!

Only open the digestion vessel under a vent hood or other exhaust system. Particular care is required when working with hydrofluoric acid (HF). Observe all relevant data sheets and safety instructions!

Never use more than one rupture disc per vessel!



Note:

Renew the vessels after around 10,000 digestion processes to maintain reliable operating conditions and to prevent negative influences on your analysis results (e.g. memory effects etc.).

Berghof Products + Instruments GmbH includes its digestion vessels in the warranty coverage. Nevertheless all of the vessels are subject to a certain aging process, which also depends on the type and frequency of the application. Typically the service life is 10,000 digestion processes or at least 3 years.

The **speedwave** four microwave oven can hold up to 24 DAP digestion vessels or up to 8 DAK-100/4 vessels. Vessel types must not be mixed as this will result in extreme differences in sample heating.

The procedure employed for all vessel types is basically similar. This section therefore first describes the general procedures, while any differences between the vessel types will be dealt with in detail in the following sections.

Sample amount Weigh the sample material into the vessels, then add the acid. The maximum sample quantity depends on the vessels employed and must be strictly observed (refer to the "Technical Specifications" section).

**Caution****Minimum fill amount!**

In each pressure vessel, at least approx. 5ml of liquid should be employed so that the temperature sensor can determine the sample temperature precisely.

The microwave oven requires a certain minimum load of approx. 20 ml of liquid. If lower volumes of liquid must be used, at least four vessels must be used for each run in order to achieve the required total load.

If the fluid amount employed is too small, the oven may be damaged during longer operation! An inadequate liquid load can also result in rotor overheating and, in the worst case, in rotor damage.

Lid placement

Visually inspect the rupture discs. In case of extensive traces of corrosion or other visible damage to the rupture discs, they must be replaced for safety reasons.

A bulge in the center of the rupture disc after use is normal and will not affect its functions.

Make sure the rupture disc is properly seated in the lid, that is, that its edge sits uniformly in the lid groove.

Press the seal lip on the appropriate molded part to spread the seal ring on the closure, then place the lid on the lower part of the vessel.

Lock the vessel

Lock the vessel with the coupling cap. Only slight pressure is needed to secure the rupture disc. Proper vessel seal is ensured by the pressure supported seal lip, even under maximum interior vessel pressure.

Vessel placement

The rotor should be loaded with the digestion vessels as symmetrically as possible and the digestion vessels connected to the receptacle. The first vessel must be inserted in the position marked "1" and the rest arranged symmetrically (refer to the "Attachment").

Any unused positions on the collection vessel should be sealed with the supplied blind stoppers or with lock screws in order to ensure the proper operation of the gas removal.

Close the microwave

Close the swiveling lid. Insert the vent tube into the oven from above until it reaches its stop and make sure that it is properly connected to an exhaust system.

The vent tube can be connected to an acid-resistant suction pump or can be connected to an existing vent system (e.g., an exhaust hood).

Close the oven door until the lock engages.

**Warning !****Hot acid vapors may be released.**

The supplied vent tubes must therefore always be properly connected and attached to an exhaust system.

Make sure the PFA tube is securely attached so that it cannot pop off its connection fitting in case of a percussive pressure burst as occurs when a rupture disc activates.

**Note:**

The desired program must be selected before the microwave oven is started.

Start program

After an appropriate application has been selected or created and the oven has been filled with the desired number of vessels the digestion program is started with "Start" in the main menu.

The following input window appears in which the program can again be modified and a file name can be input. If file names are identical the index is automatically raised by 1.

**Note:**

If the program is modified at this stage of operation the modification affects only the current run, but not the stored application.

Number of samples

Again check if the setting is for the correct type of vessel and input the **number** of samples.

start with application:

Calcite; Dolomite

| | T | p | ramp | time | power |
|---|-----|----|------|------|-------|
| 1 | 155 | 50 | 2 | 15 | 90 |
| 2 | 200 | 50 | 10 | 30 | 90 |
| 3 | 50 | 0 | 1 | 15 | 0 |
| 4 | 50 | 0 | 1 | 1 | 0 |
| 5 | 50 | 0 | 1 | 1 | 0 |

vessel: number:

store to file: index: pressure:

start digestion

esc

Before file name may be modified the following dialog window is opened. Therein file name be changed and indeces may be reset to 0.

start with application:

Calcite; Dolomite

| | T | p | ramp | time | power |
|---|-----|----|------|------|-------|
| 1 | 155 | 50 | 2 | 15 | 90 |
| 2 | 200 | 50 | 10 | 30 | 90 |
| 3 | 50 | 0 | 1 | 15 | 0 |
| 4 | 50 | 0 | 1 | 1 | 0 |
| 5 | 50 | 0 | 1 | 1 | 0 |

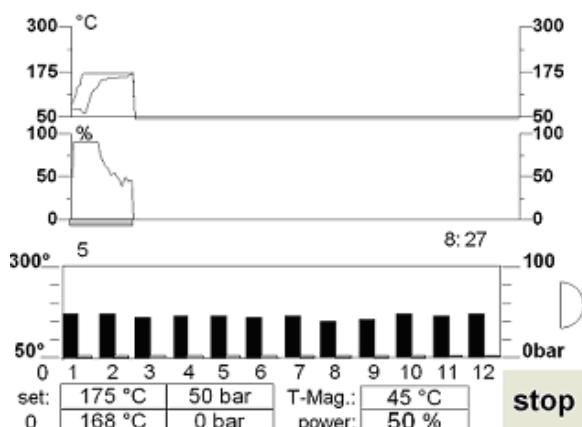
vessel: number:

store to file: index: pressure:

start digestion

esc

Now start the application in line **Start Digestion**. The temperature profile will be displayed graphically. After an initial period of approx. 20 sec. heating starts.



The program can be canceled at any time by pressing the **stop** key.



Note:

The magnetron cannot be switched on while the microwave is open!
If you wish to open the microwave, stop the program first!

The program can be canceled at any time by pressing the **stop** key.

Real time display

During digestion the highest sample temperature and pressure curve is displayed as are all temperatures inside the vessels in the form of a bar graph. In addition the target temperature/pressure is **set** and beneath this the maximum temperature/pressure displayed. As long as a temperature is below 50 °C it is indicated only as "low". No vapor pressures worth mentioning occur within this temperature range.

Furthermore, the magnetron temperature, T-Mag and the microwave power output power are displayed.

Besides the pressure, in the middle graph the microwave output or magnetron temperature can be displayed optionally. For this purpose please press **T-Mag** or **power**.

If the system is operated with pressure measurement, all internal pressures of the vessels are represented as bars and the highest internal pressure of a vessel is displayed.

**Note:**

When turntable DAP-40+ is used sample temperatures of the outer circle are monitored continuously and microwave power is controlled according to the highest temperature. 12position display corresponds to the temperature distribution of the 16 vessels in the outer circle. Only pos. 1, 4, 7 and 10 give the correct temperatures of vessels 1, 5, 9 and 13.

Comment

After digestion has finished a comment can be input.

| |
|--|
| digestion finished |
| data will be stored on file: |
| data_file1 |
| type in comment: |
| sample 1 134mg |
| <input type="button" value="finish"/> <small>stopped_user</small> |

To enter the comment, select the appropriate comment line and enter the text by means of the keyboard.

By pressing **finish** you return to the main window. All data are memorized automatically and can be reprocessed at any time as described under 'Data Reprocessing'.

**Note:**

The magnetron cannot be switched on while the microwave is open!
 If you wish to open the microwave, stop the program first!
 The program can be canceled at any time by pressing the **stop** key.

**Caution**

If possible, do not operate the oven unsupervised, e.g., overnight.

4.3. Sample Loading

4.3.1. Handling the DAP-40+, DAP-30+, DAP-60+, and DAP-100+ Pressure Vessels

The DAP pressure vessels are made up of a TFM pressure vessel, an aluminum rupture disc, a TFM lid, and a coupling cap. The PP rotor can hold up to 12 DAP-60+ vessels.



Small weighed-in sample quantities

Weigh the sample material into the vessels. The maximal weighing-in quantity, which depends on the vessels, must be borne in mind (see 'Technical Data' section).

Weighing-in using TFM weighing cups

To simplify the weighing process and prevent loss of samples the samples can be weighed directly into the Berghof weighing cups made from TFM. These are placed in the digestion vessel with the sample and remain there during digestion. After digestion and thorough rinsing with distilled water they can be reused.



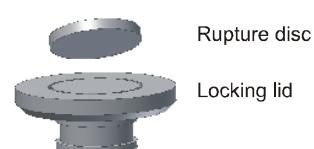
Adding the acid

Now add the acid mixture. Pay attention to the maximum and minimum filling quantity, which depends on the vessels. (Refer to 'Technical Data').

Rupture disc

Visually inspect the rupture disc. In case of extensive traces of corrosion or other visible damage to the rupture disc, it must be replaced for safety reasons.

A bulge in the center of the rupture disc after use is normal and will not affect its functions. Make sure the rupture disc is properly seated in the locking lid, that is, that its edge sits uniformly in the lid groove.



Rupture disc

Locking lid

When using a TFM lid/rupture disk combination of the type offered especially for digestion processes subject to maximum cleanliness requirements, the rupture disk is not required.



DANGER !

Rupture discs!

Use only digestion vessels and spare parts authorized by Berghof Products + Instruments GmbH for use with the **speedwave**. These can be obtained either from your local dealer or directly from Berghof Products + Instruments GmbH (Refer to the "Repairs / Customer Service" section for contact addresses).

The pressure vessels are equipped with a rupture disc which produces a spontaneous pressure release upwards through the screw-on tube connections in case of excessive vessel pressure. In some cases, such a spontaneous pressure release may occur after the vessel has been removed from the microwave oven.

Never use more than one rupture disc per vessel!

Install the lid

From time to time, press the locking lid seal lip on the appropriate molded part to spread it, and place the lid on the lower part of the vessel.



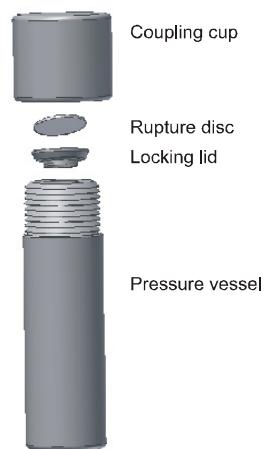
Alternatively the sealing lip of the locking lid can be dilated in the forming station. The stamp is wound downwards as far as possible. This station permits a more even dilation of the sealing lip and is recommended in particular for DAP-100+, DAK-17 and DAK-100/4.



Distinct resistance must be felt when the lid is placed on the pressure vessel. If no resistance is felt, the seal lip must be spread as described above.

Close the vessel

After the sample has been weighed in and the acid has been added, place the seal lid on vessel and close it **hand-tight** with the coupling cap. Only slight pressure is needed to secure the rupture disc. Proper vessel seal is ensured by the pressure supported seal lip, even under maximum interior vessel pressure.

**Caution**

The maximum sample quantity depends on the vessels employed and must be strictly observed (refer to the "Technical Specifications" section).

**Caution****Minimum fill amount!**

In each pressure vessel, at least approx. 5ml of liquid should be employed so that the temperature sensor can determine the sample temperature precisely.

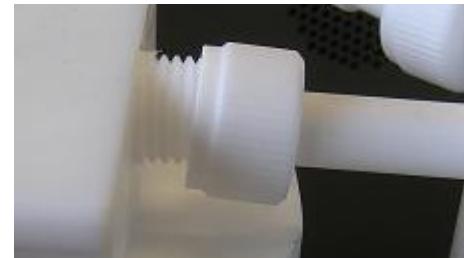
The microwave oven requires a certain minimum load of approx. 20 ml of liquid. If lower volumes of liquid must be used, at least four vessels must be used for each run in order to achieve the required total load.

If the fluid amount employed is too small, the oven may be damaged during longer operation! An inadequate liquid load can also result in rotor overheating and, in the worst case, in rotor damage.

Vessel placement

Digestion vessels should be distributed as symmetrically as possible around the rotor (see '*appendix*').

During placement, the vent fitting is simply screwed onto the associated collection vessel tube (it may be necessary to first move the vessel into the proper position).



Any unused positions on the collection vessel should be sealed with the supplied blind stoppers or with lock screws in order to ensure the proper operation of the gas removal.



4.3.2. Handling DAQ-20H Pressure Vessels



Warning !

Breakage hazard!

Hand-tighten the quartz glass lids.
Excessive tightening can destroy the vessels!

The procedure for the quartz glass inserts DAQ-20 with pressure vessels DAP-60+ or DAP-100+ is largely identical to the procedure for pressure vessels without quartz glass inserts. Only the changes in the steps of the procedure are therefore described here.

DAQ-20H pressure vessels consist of a quartz insert (pressure vessel), a Monel rupture disc, a rupture disc retainer ring, and a TFM lid.

The vessel structure is illustrated below.



Rupture disc

Visually inspect the rupture disc. In case of extensive traces of corrosion or other visible damage to the rupture disc, it must be replaced for safety reasons. A bulge in the center of the rupture disc after use is normal and will not affect its functions. Make sure the rupture disc is properly seated in the retainer ring.



Rupture disc
Locking lid



DANGER !

Rupture discs!

Use only digestion vessels and spare parts authorized by Berghof Products + Instruments GmbH for use with the **speedwave**. These can be obtained either from your local dealer or directly from Berghof Products + Instruments GmbH (Refer to the "Repairs / Customer Service" section for contact addresses).

The pressure vessels are equipped with a rupture disc which produces a spontaneous pressure release upwards through the screw-on tube connections in case of excessive vessel pressure. In some cases, such a spontaneous pressure release may occur after the vessel has been removed from the microwave oven.

Never use more than one rupture disc per vessel!

Close the DAQ-10

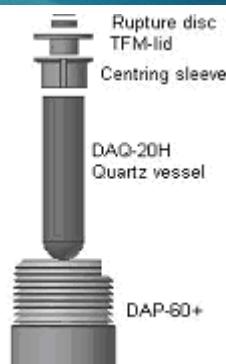
Prior to every use, press the locking lid seal lip on the appropriate molded part to spread it, and place the lid on the glass insert.



Distinct resistance must be felt when the lid is placed on the glass insert. If no resistance is felt, the seal lip must be spread as described above.

Insert the closed quartz vessel into the DAP-60+ or DAP-100+ vessel.

Close the DAP-vessel **hand-tight** with the coupling cap. Only slight pressure is needed to secure the rupture disc. Proper vessel seal is ensured by the pressure supported seal lip, even under maximum interior vessel pressure.

**Caution**

The maximum sample quantity depends on the vessels employed and must be strictly observed (refer to the "Technical Specifications" section).

Caution**Minimum fill amount!**

In each pressure vessel, at least approx. 5ml of liquid should be employed so that the temperature sensor can determine the sample temperature precisely.

The microwave oven requires a certain minimum load of approx. 20 ml of liquid. If lower volumes of liquid must be used, at least four vessels must be used for each run in order to achieve the required total load.

If the fluid amount employed is too small, the oven may be damaged during longer operation! An inadequate liquid load can also result in rotor overheating and, in the worst case, in rotor damage.

Warning !**Breakage hazard!**

Hand-tighten the quartz glass lids. Excessive tightening can destroy the vessels!

The further procedure, beginning with "inserting the vessels into the microwave" is identical with the procedure described in *Handling the pressure vessels DAP-30+, DAP-60+ and DAP-100+*.

4.3.3. Handling DAC-17 Pressure Vessels

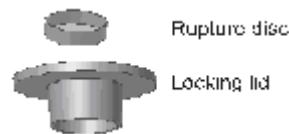
The procedure for the DAC-17 inserts with pressure vessels DAP-100+ is largely identical to the procedure for pressure vessels without inserts. Only the changes in the steps of the procedure are therefore described here.

DAC-17 pressure vessels consist of a TFM insert (pressure vessel), a ceramic pressure jacket, a Monel rupture disc, a rupture disc retainer ring, and a TFM lid.

The vessel structure is illustrated below.

Rupture disc

Visually inspect the rupture disc. In case of extensive traces of corrosion or other visible damage to the rupture disc, it must be replaced for safety reasons. A bulge in the center of the rupture disc after use is normal and will not affect its functions. Make sure the rupture disc is properly seated in the retainer ring.



DANGER !

Rupture discs!

Use only digestion vessels and spare parts authorized by Berghof Products + Instruments GmbH for use with the **speedwave**. These can be obtained either from your local dealer or directly from Berghof Products + Instruments GmbH (Refer to the “Repairs / Customer Service” section for contact addresses).

The pressure vessels are equipped with a rupture disc which produces a spontaneous pressure release upwards through the screw-on tube connections in case of excessive vessel pressure. In some cases, such a spontaneous pressure release may occur after the vessel has been removed from the microwave oven.

Never use more than one rupture disc per vessel!

Close the DAC-17

Prior to every use, press the locking lid seal lip on the appropriate molded part to spread it, and place the lid on the TFM insert.



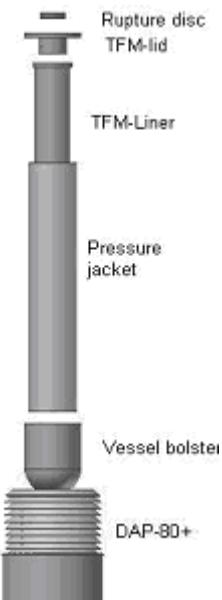
Alternatively the sealing lip of the locking lid can be dilated in the forming station. The stamp is wound downwards as far as possible. This station permits a more even dilation of the sealing lip and is recommended in particular for DAP-100+, DAK-17 and DAK-100/4.



Distinct resistance must be felt when the lid is placed on the TFM insert. If no resistance is felt, the seal lip must be spread as described above.

First insert the vessel bolster, then the ceramic pressure jacket and finally the closed DAC-17 vessel into the DAP-100+ vessel.

Close the DAP-vessel **hand-tight** with the coupling cap. Only slight pressure is needed to secure the rupture disc. Proper vessel seal is ensured by the pressure supported seal lip, even under maximum interior vessel pressure.



Caution The maximum sample quantity depends on the vessels employed and must be strictly observed (refer to the "Technical Specifications" section).

Caution **Minimum fill amount!**
In each pressure vessel, at least approx. 5ml of liquid should be employed so that the temperature sensor can determine the sample temperature precisely.
The microwave oven requires a certain minimum load of approx. 20 ml of liquid. If lower volumes of liquid must be used, at least four vessels must be used for each run in order to achieve the required total load.
If the fluid amount employed is too small, the oven may be damaged during longer operation! An inadequate liquid load can also result in rotor overheating and, in the worst case, in rotor damage.

The further procedure, beginning with "inserting the vessels into the microwave" is identical with the procedure described in *Handling the pressure vessels DAP-30+, DAP-60+ and DAP-100+*.

4.3.4. Handling DAK-100/4 Pressure Vessels

The DAK-100/4 pressure vessels consist of the TFM pressure vessel, a Monel rupture disc, a TFM lid, and a TFM coupling cap.

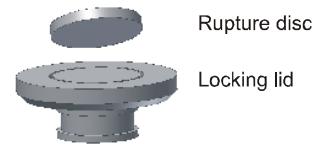
The PP rotor can hold up to 8 DAK-100/4 vessels.



Rupture disc

Visually inspect the rupture disc. In case of extensive traces of corrosion or other visible damage to the rupture disc, it must be replaced for safety reasons.

A bulge in the center of the rupture disc after use is normal and will not affect its functions. Make sure the rupture disc is properly seated in the lid, that is, that its edge sits uniformly in the lid groove.



DANGER !

Rupture discs!

Use only digestion vessels and spare parts authorized by Berghof Products + Instruments GmbH for use with the **speedwave**. These can be obtained either from your local dealer or directly from Berghof Products + Instruments GmbH (Refer to the “Repairs / Customer Service” section for contact addresses).

The pressure vessels are equipped with a rupture disc which produces a spontaneous pressure release upwards through the screw-on tube connections in case of excessive vessel pressure. In some cases, such a spontaneous pressure release may occur after the vessel has been removed from the microwave oven.

Never use more than one rupture disc per vessel!

Install the lid

From time to time, press the locking lid seal lip on the appropriate molded part to spread it, and place the lid on the lower part of the vessel.

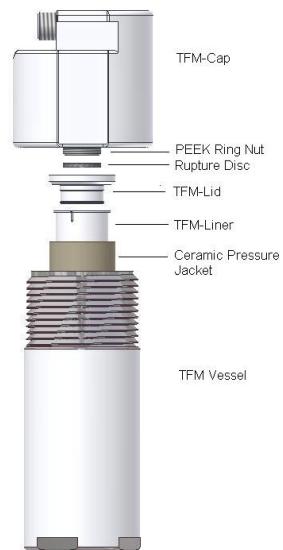


Alternatively the sealing lip of the locking lid can be dilated in the forming station. The stamp is wound downwards as far as possible. This station permits a more even dilation of the sealing lip and is recommended in particular for DAP-100+, DAK-17 and DAK-100/4.

**Close the vessel**

Distinct resistance must be felt when the lid is placed on the pressure vessel. If no resistance is felt, the seal lip must be spread as described above.

After the sample has been weighed in and the acid has been added, place the seal lid on vessel and close it *hand-tight* with the coupling cap. Only slight pressure is needed to secure the rupture disc. Proper vessel seal is ensured by the pressure supported seal lip, even under maximum interior vessel pressure.



Caution The maximum sample quantity depends on the vessels employed and must be strictly observed (refer to the "Technical Specifications" section).

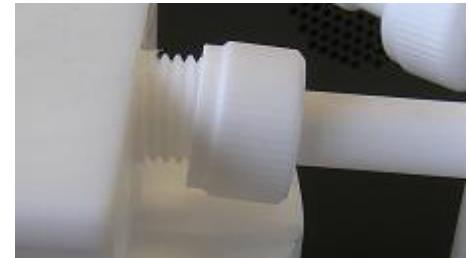


Caution Minimum fill amount!
In each pressure vessel, at least approx. 5ml of liquid should be employed so that the temperature sensor can determine the sample temperature precisely. The microwave oven requires a certain minimum load of approx. 20 ml of liquid. If lower volumes of liquid must be used, at least four vessels must be used for each run in order to achieve the required total load. If the fluid amount employed is too small, the oven may be damaged during longer operation! An inadequate liquid load can also result in rotor overheating and, in the worst case, in rotor damage.

Vessel placement

Digestion vessels should be distributed as symmetrically as possible around the rotor (see 'appendix').

During placement, the vent fitting is simply screwed onto the associated collection vessel tube (it may be necessary to first move the vessel into the proper position).



Any unused positions on the collection vessel should be sealed with the supplied blind stoppers or with lock screws in order to ensure the proper operation of the gas removal.



4.4. Sample Removal

After the microwave switches off, the vessels must remain in the oven for at least 10 minutes. After this time, all vessels can be removed (disconnect the vent tube first!) and can be placed under an vent hood or other exhaust system for further cooling. Acid vapors can leak out of the vessels during the cooling phase. This is due to the flow behavior of TFM and, generally, does not result in any sample loss or contamination.

The vessels may only be opened after an adequate cooling period. When the vessels are opened, their internal temperatures should not lie above 100°C (212°F). The length of the cooling period depends on the heating time and the digestion temperature. The total cooling time before the vessels are opened should be at least half the digestion time and, if possible, somewhat more than this.



Warning !

Burn and acid burn hazard!

The digestion vessels must not be removed from the oven for at least 10 minutes after the end of the digestion program. This will ensure that the samples have cooled sufficiently to avoid rupture disc breakage caused by jarring during removal.

Always wear safety glasses/goggles and protective gloves when opening vessels!

Always work under an vent hood or other exhaust system!

Never point the gas outlet towards yourself or anyone else. Aggressive gases are released from here when the vessels are opened or if the rupture disc activates!

4.4.1. Removing and Opening DAP-40+, DAP-30+, DAP-60+ and DAP-100+ Pressure Vessels

A total cooling time of at least 20 minutes is required for these vessels.



DANGER !

Pressure vessels!

Always wear safety glasses/goggles and protective gloves when working with the pressure vessels!

Never attempt to use force to open the vessels. Never use tools to open the vessels!

The pressure vessels are equipped with a rupture disc which produces a spontaneous pressure release upwards through the screw-on tube connections in case of excessive vessel pressure. In some cases, such a spontaneous pressure release may occur after the vessel has been removed from the microwave oven.

Hot gases and vapors may be released from the digestion vessel when it is opened! Always make sure the vent opening on pressure vessels faces away from both yourself and other individuals!!

Only open the digestion vessel under a vent hood or other exhaust system. Particular care is required when working with hydrofluoric acid (HF). Observe all relevant data sheets and safety instructions!



Warning !

Residual pressure in vessels!

Even after cooling, a residual pressure will remain in the vessels!

Always wear safety glasses/goggles and protective gloves when opening vessels!

Always work under an vent hood or other exhaust system!

Never point the gas outlet towards yourself or anyone else. Aggressive gases are released from here when the vessels are opened or if the rupture disc activates!



Caution

If there is still a high residual pressure in the vessel, it will be difficult to unscrew the lid. If in doubt, allow the vessel to cool for an additional period of time!

If the solution has a high CO₂ content, opening the vessel too quickly can cause the solution to foam up, resulting in sample loss!

Opening the vessels

To open the vessels, hold onto the coupling cap and slowly turn the vessel clockwise. Make sure the gas outlet always faces away from you.

As gases begin to escape from the vessel, wait a moment or slightly close the vessel by turning it counterclockwise. Continue in this manner and gradually open the vessel.



4.4.2. Removing and Opening DAK-100/4 Pressure Vessels

A total cooling time of at least 30 minutes is required for these vessels.



DANGER ! Pressure vessels!

Always wear safety glasses/goggles and protective gloves when working with the pressure vessels!

Never attempt to use force to open the vessels.

The pressure vessels are equipped with a rupture disc which produces a spontaneous pressure release upwards through the screw-on tube connections in case of excessive vessel pressure. In some cases, such a spontaneous pressure release may occur after the vessel has been removed from the microwave oven.

Hot gases and vapors may be released from the digestion vessel when it is opened! Always make sure the vent opening on pressure vessels faces away from both yourself and other individuals!!

Only open the digestion vessel under a vent hood or other exhaust system. Particular care is required when working with hydrofluoric acid (HF). Observe all relevant data sheets and safety instructions!



Warning ! Residual pressure in vessels!

Even after cooling, a residual pressure will remain in the vessels!

Always wear safety glasses/goggles and protective gloves when opening vessels!

Always work under an vent hood or other exhaust system!

Never point the gas outlet towards yourself or anyone else. Aggressive gases are released from here when the vessels are opened or if the rupture disc activates!



Caution

If there is still a high residual pressure in the vessel, it will be difficult to unscrew the lid. If in doubt, allow the vessel to cool for an additional period of time!

If the solution has a high CO₂ content, opening the vessel too quickly can cause the solution to foam up, resulting in sample loss!

Opening the vessels

The vessel must be placed on the opening station and make sure the gas outlet always faces away from you.

To open the vessels, slowly turn the vessel clockwise. As gases begin to escape from the vessel, wait a moment or slightly close the vessel by turning it clockwise. Continue in this manner and gradually open the vessel.

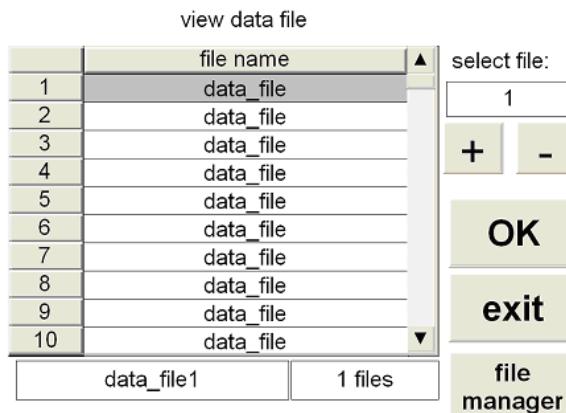
Once the pressure has been completely released, you can open the aluminum cap by hand and remove the TFM lid.



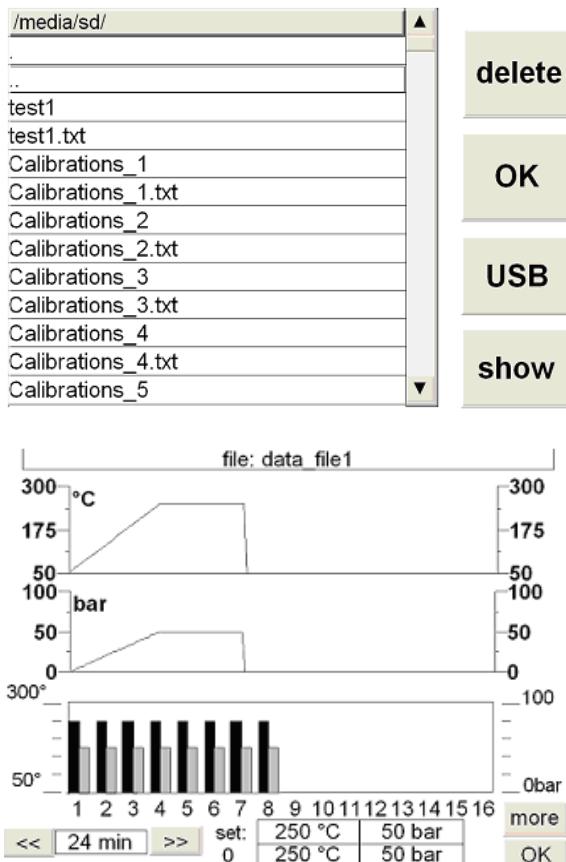
4.5. Data Reprocessing

The temperature and pressure development during a digestion process is recorded individually for each vessel and, if need be, saved after digestion has been completed. Prior to saving the index of the data file is automatically incremented.

Data in the main menu serves to plot stored temperature developments on the screen. To start with the file system is opened. Several individual files can have been stored under each file name. The number is displayed at bottom right.



OK is used to call a selected file and have it represented graphically. **Exit** takes you back to the main menu. The file manager takes you to a representation of all stored files incl. txt files that can be exported to Excel or a similar program.



File: The current file name is displayed and by selecting this field it can be renamed.

OK

Exit the menu item to the main menu.

<< and >>

The entire time range can be scrolled through using the **<<** and **>>** arrow buttons; during this the selected point in time is displayed in the time window (bottom left). It is always represented in a 60-minute window. If digestion takes longer, you change to the next lower or higher time window using the **<<** and **>>** arrow buttons.

In addition the target temperature/pressure are **set** and beneath this the maximum temperature/pressure displayed.

Single curve representation:

By selecting the corresponding vessel number in the lower bar chart the temperature and pressure development of this vessel is displayed.

more

Display of the temperature program and further information such as the date, time and comments.

| file: data_file | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|--------|------------|--------|-----------|-------|-----|--------|------------|--------|-----------|-------|----|-----|----|-----|----|----|---|----|---|---|---|---|---|----|---|---|---|---|---|----|---|---|---|---|---|----|---|---|---|---|
| comments: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| temp messung an leere stellen | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr> <th></th> <th>T</th> <th>p</th> <th>ramp</th> <th>time</th> <th>power</th> </tr> <tr> <td>1</td> <td>210</td> <td>50</td> <td>1</td> <td>25</td> <td>90</td> </tr> <tr> <td>2</td> <td>50</td> <td>0</td> <td>1</td> <td>1</td> <td>0</td> </tr> <tr> <td>3</td> <td>50</td> <td>0</td> <td>1</td> <td>1</td> <td>0</td> </tr> <tr> <td>4</td> <td>50</td> <td>0</td> <td>1</td> <td>1</td> <td>0</td> </tr> <tr> <td>5</td> <td>50</td> <td>0</td> <td>1</td> <td>1</td> <td>0</td> </tr> </table> | | | | | | | T | p | ramp | time | power | 1 | 210 | 50 | 1 | 25 | 90 | 2 | 50 | 0 | 1 | 1 | 0 | 3 | 50 | 0 | 1 | 1 | 0 | 4 | 50 | 0 | 1 | 1 | 0 | 5 | 50 | 0 | 1 | 1 | 0 |
| | T | p | ramp | time | power | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 210 | 50 | 1 | 25 | 90 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | 50 | 0 | 1 | 1 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | 50 | 0 | 1 | 1 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | 50 | 0 | 1 | 1 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | 50 | 0 | 1 | 1 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr> <th>int</th> <th>p-band</th> <th>total time</th> <th>vessel</th> <th>mag temp.</th> </tr> <tr> <td>20</td> <td>20</td> <td>34</td> <td>3</td> <td>120</td> </tr> </table> | | | | | | int | p-band | total time | vessel | mag temp. | 20 | 20 | 34 | 3 | 120 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| int | p-band | total time | vessel | mag temp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | 20 | 34 | 3 | 120 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| date: DT#2008-06-10-10:55:47 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

OK

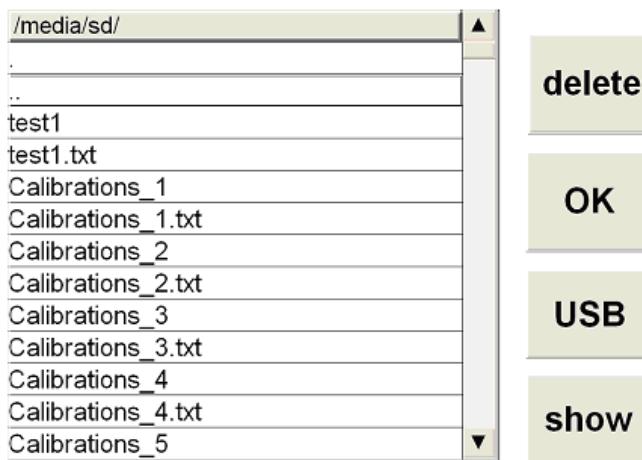


Note:

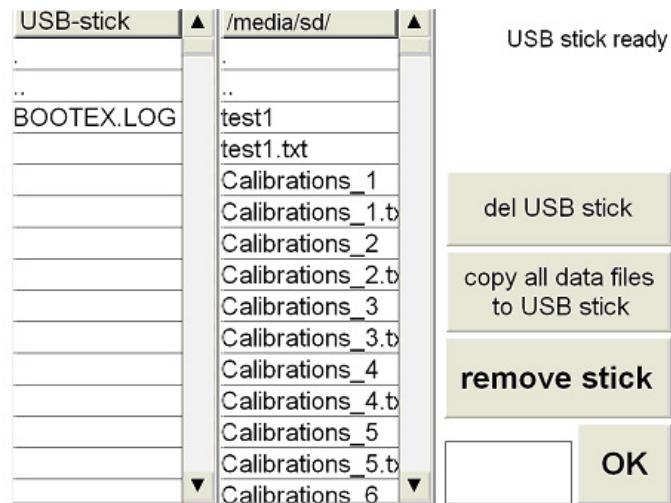
When turntable DAP-40+ is used sample temperatures of the outer circle are monitored continuously and microwave power is controlled according to the highest temperature. 12position display corresponds to the temperature distribution of the 16 vessels in the outer circle. Only pos. 1, 4, 7 and 10 give the correct temperatures of vessels 1, 5, 9 and 13.

4.6. Data backup / data export using USB

The file manager takes you to a representation of all stored files incl. txt files that can be exported into Excel or a similar program.



To export data you plug a Memory Stick into the USB port and press **USB**.



In the following menu you can delete all files on the Memory stick, copy all of the data from the speedwave four onto the Memory stick and remove the Memory stick again. In all of the steps attention must be paid to the status message at top right.

Bear in mind that only the same Memory stick may be used all the time. If you wish to copy data onto a 2nd Memory stick, the control unit must be switched off and on again.

The digestion data are stored in a binary format which can only be read by means of the speedwave four control unit.

Besides, all data are also stored in txt format, which can then be imported to Excel or Word on your computer.

Txt-Datenformat:

Data records are recorded at 15-second intervals.

Each line contains a complete data record of the vessel consisting of:

T-max; 12x T-ist; dummy; T-soll; dummy; dummy; p-max; 12x p-ist; p-soll; power; magT; T-max; 12x T-actual; T-target; dummy; dummy; p-max; 12xp-actual; p-target; power; magT;

Blank line

Program parameters with one program step represented per line

Date and time

5. Options

5.1. Evaporating Unit



DANGER ! **Explosion hazard!**

Do not use perchloric acid.

No organic solvents (alcohols, hydrocarbons, etc.) may be placed in the pressure vessels or the microwave.

Highly reactive substances which spontaneously react at higher temperatures or in the presence of oxidizing agents or which may be nitrated and are potentially explosive may not be digested in the microwave. Examples of such substances include: explosives (TNT, etc.), perchlorates, ether, pyrophoric substances, etc.



Warning ! **Always wear eye protection!**

Always wear safety glasses/goggles and protective gloves during work which may involve contact with chemicals, that is, when working with acids, pressure vessels, during cleaning, etc.



3-stage gas scrubber system

Connection for water cooling

Gas exhaust

PFA tube

After connecting the condensation unit to the vent tube, the unit can also be employed to evaporate acids. For this process, the pressure vessels are operated with a special screw-on cap, without Teflon® lid. The vent tube used for evaporating is equipped with a temperature sensor which must be connected to the socket provided for this purpose on the rear of the unit.

The **speedwave four** microwave evaporating unit is used to concentrate acids or sample digestion solutions obtained after digestion procedures employing HNO₃, HCl, HF, and water by means of distillation at ambient pressure. The escaping acid vapors are condensed and neutralized in a 3-stage, water-cooled gas scrubber system.

The unit is not suited for concentrating acids or liquids with a boiling point above 200 °C (392 °F) such as sulfuric and phosphoric acid. For safety reasons (explosion hazards) the use of perchloric acid and organic solvents is prohibited.



Warning ! **Hot acid vapors are generated!**

Hot acid vapors are generated during evaporating. Take particular care to ensure that all connections are secure and do not leak. In particular, the tube connection between the microwave and the gas scrubber must always be totally sealed.

Secure the tube appropriately to ensure that no acid vapors can escape in the direction of surrounding individuals, even when the screw-on connection is opened.

The microwave system, together with the gas scrubber, must be set up under a vent hood.

5.1.1. Standard Delivery

Refer to "Standard Delivery" in the "Setup and Commissioning" section.

5.1.2. Installation and Commissioning

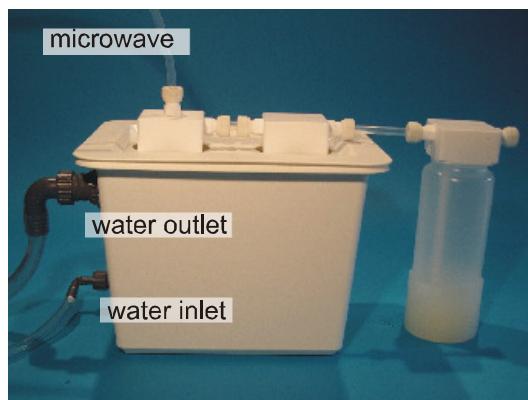
Ambient conditions

Aside from the requirements cited in the "Ambient Conditions" section of the chapter "Setup and Commissioning", the operation of the gas scrubber also requires a coolant water connection (approx. 0.5 liters/min. with an inlet temperature not exceeding 20 °C, 68 °F). In addition, there is also the need for an increased space of 53 x 27 cm (20.9 x 10.6 inch).

Due to the hot acid vapors generated, the microwave oven and the gas scrubber system must be set up under a vent hood or other exhaust system. The exhaust chamber must always remain securely closed during the entire evaporating process.

Gas scrubber

As illustrated in the figures below, add marble granulate to 2 of the gas scrubber bottles (fill each approx. half-way) while filling the third bottle with NaOH solution (at least 0.5 mol/l NaOH). Connect the bottles as illustrated in the figures and place the bottles filled with marble granulate in the cooler. Connect the cooler to a coolant water system with a maximum water temperature of 20 °C (68 °F). The coolant water flowrate must be approx. 0.5 liters/min.



5.1.3. Operation



Warning ! Always wear eye protection!

Always wear safety glasses/goggles and protective gloves during work which may involve contact with chemicals, that is, when working with acids, pressure vessels, during cleaning, etc.!

Lid replacement

After the samples have been digested and cooled in the microwave, they are opened as described in the “*Sample Removal*” section. The lid for evaporating is then screwed on.



DANGER ! Explosion hazard!

It is important that the lid with the rupture disc be removed for evaporating and that it is never used for this procedure.



DAK-100/4

Evaporating cap



DAP-60+

Evaporating cap Digestion lid

Sample placement

Place the vessels prepared for evaporating into the rotor. Any unused positions must be sealed with blind stoppers. Then connect all vessels to the collection vessel.

Concentration must always be carried out with a fully filled rotor (8 vessels for DAK-100/4 or 12 vessels for DAP-vessels). The sample volume must be nearly equal in all vessels (e.g., 20 ml).



Gas scrubber connection

Close the microwave and connect the vent hose. This connects the microwave to the gas scrubber. Check to make sure that sufficient coolant water is flowing at the gas scrubber (approx. 0.5 liters/min.).

Start the microwave

For fortification the magnetron temperature must be set to magT < 20 °C in the temperature program (typical values 5-10 °C). The magnetron temperature is recorded continuously and is used to control the distillation process. The terminate criterion is met if in step 5 the magnetron temperature rises by the specified value compared to the temperature that arose in step 4.

The power specifications for step 4 and must be selected to be identical to obtain an expedient terminate criterion. In steps 1-4 the microwave energy is not automatically cut off. The times these steps take depends on the total quantity of fluid and must therefore be selected in such manner that the temperatures of all samples can stabilize. In step 5 the distillation process is stopped automatically as soon as the terminate criterion is met. The entire control system is therefore independent of the type of acid.

Example

| Evaporation | | | | | |
|--|-------------|------------|---------------------------------|------|-------|
| select as your application (0...12): 0 | | | | | |
| | temperature | pressure | ramp | time | power |
| 1 | 130 | 50 | 1 | 10 | 90 |
| 2 | 130 | 50 | 1 | 2 | 70 |
| 3 | 130 | 50 | 1 | 2 | 70 |
| 4 | 130 | 50 | 1 | 10 | 70 |
| 5 | 130 | 50 | 1 | 10 | 70 |
| int | p-band | total time | vessel | magT | |
| 1 | 0 | 39 | 3 | 10 | |
| <input style="width: 100px; height: 25px; background-color: #e0e0e0; border: 1px solid black; font-weight: bold; font-size: 10pt; color: black; padding: 2px; margin-right: 10px;" type="button" value="save + exit"/> <input style="width: 100px; height: 25px; background-color: #e0e0e0; border: 1px solid black; font-weight: bold; font-size: 10pt; color: black; padding: 2px;" type="button" value="exit"/> | | | Evaporation switched on! | | |

Start the microwave.

The samples are not evaporated until they are dry. As a rule, a residual volume of 1-2ml remains. In order to concentrate the sample still further, the times in step 1-4 must be increased.

Sample removal

The samples are removed as described in the “*Sample Removal*” section.

Maintenance

The evaporated acid is condensed and collected in the two gas scrubber bottles. The acid is neutralized by the marble granulate. The liquid must be poured off as soon as the gas scrubber bottles are approx. three-quarters full. The granulate can continue to be used until it has gone completely into solution. The granulate can neutralize approximately 2 liters of acid. A portion of the acid vapors are also concentrated in the rotor’s collection vessel. This liquid must be removed after every fuming procedure (refer to the “*Cleaning*” section).

All TFM components must be cleaned with water and dried before they are again used.

6. Maintenance, Troubleshooting and Service

6.1. Cleaning

**DANGER !****Acid burn hazard!**

Use only digestion vessels and spare parts authorized by Berghof Products + Instruments GmbH for use with the **speedwave**. These can be obtained either from your local dealer or directly from Berghof Products + Instruments GmbH (Refer to the "Repairs / Customer Service" section for contact addresses).

Always wear safety glasses/goggles and protective gloves when working with the pressure vessels!

Note any changes in the appearance of the pressure vessel which could indicate possible material fatigue, e.g., deformation of the vessel, difficulty screwing on lids, etc. even when the vessel is cold and not under pressure. All such vessels should be immediately returned to Berghof Products + Instruments GmbH for inspection.

**Warning !****Always wear eye protection!**

Always wear safety glasses/goggles and protective gloves during work which may involve contact with chemicals, that is, when working with acids, pressure vessels, during cleaning, etc.!

Oven chamber

The oven should be wiped out with a moist cloth at regular intervals as well as after any rupture disc activation. All relevant safety measures should be observed in case of contamination by acids, particularly hydrofluoric acid. Allow the oven to thoroughly dry before again using it!

Display/Keyboard

Use only a dry cloth to wipe off the display and the keyboard.

Vessels

Since the vessels exhibit practically no memory effects it is generally sufficient to thoroughly rinse out the vessels with distilled water after each digestion procedure involving complete digestion. If discoloration is noted or if carry-over is suspected, the vessels are cleaned by a blank digestion using acid. In this case, the acid used for the particular application is filled into the vessel, but no sample is added. After filling, the temperature program for the application in question is started.

Cap for pressure control

From time to time the glass rings in the lids used to measure pressure must be cleaned. This becomes necessary when the signal from a given vessel significantly deviates from those from the other vessels.

To do this, first unscrew and remove the prism and vent nipple and use the long, thin edge of the supplied tool to push the TFM separating block out with the long. All components can then be cleaned with water and dried. Replace the silicon seals as required.

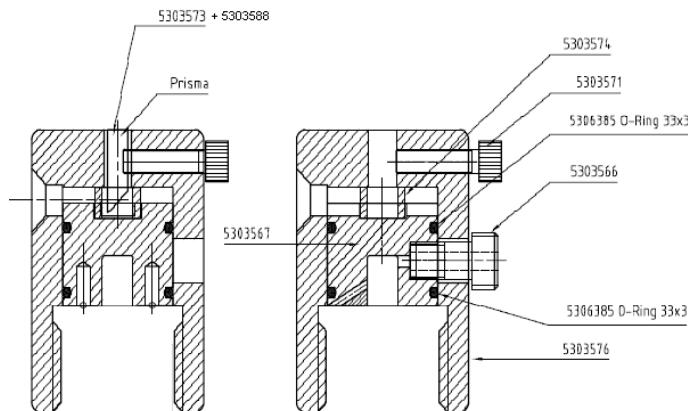
Reinstall the glass ring by laying it on the TFM separating block, then pushing the block into the lid. Using the wide edge of the tool, which can be identified by the two metal nipples, turn the separating block inside the lid until the vent nipple can be screwed in.

Replace the polarisation foil at the prism and insert prism again. Please observe correct orientation of the prism.

Finally pressure measurement has to be aligned newly (see chapter 'Alignement of pressure measurement')

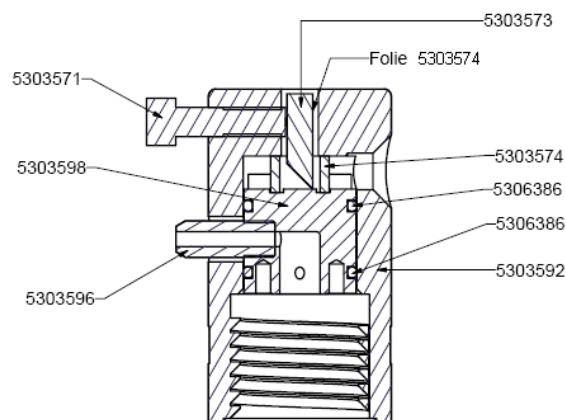
Cap for pressure control with

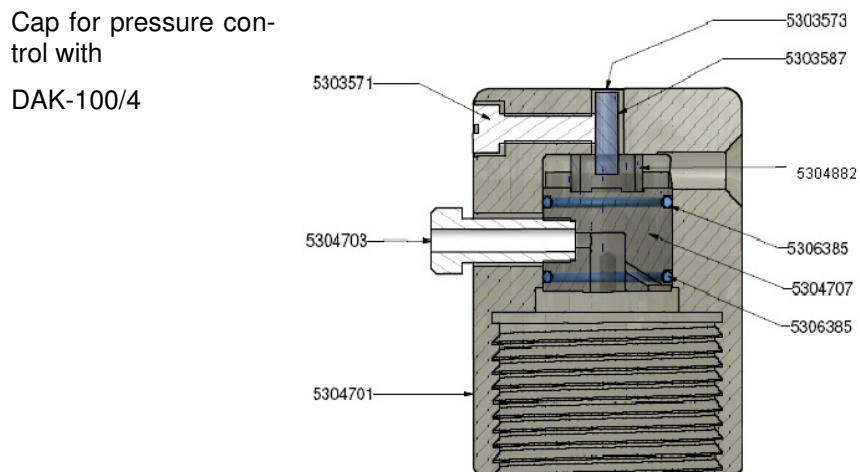
DAP-30/60/100+



Cap for pressure control with

DAP-40+



**Rotor system**

If a rupture disc has activated, perform the following procedure:

- First, gases in the collecting system and hoses may be suctioned by connecting a acid-proofed pump to the exhaust tube (e.g. a water jet pump).
- Remove all vessels from the rotor and open them as described in the *“Sample Removal”* section.
- Remove the collection system.
- Rinse all components clean and allow them to dry.
- Reinstall the rotor and the collection system.

6.2. Maintenance



DANGER ! Acid burn hazard!

Use only digestion vessels and spare parts authorized by Berghof Products + Instruments GmbH for use with the **speedwave**. These can be obtained either from your local dealer or directly from Berghof Products + Instruments GmbH (Refer to the “*Repairs / Customer Service*” section for contact addresses).

Always wear safety glasses/goggles and protective gloves when working with the pressure vessels!

Note any changes in the appearance of the pressure vessel which could indicate possible material fatigue, e.g., deformation of the vessel, difficulty screwing on lids, etc. even when the vessel is cold and not under pressure. All such vessels should be immediately returned to Berghof Products + Instruments GmbH for inspection.

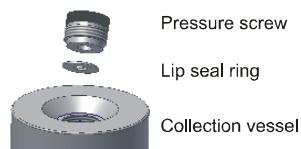


Warning ! Always wear eye protection!

Always wear safety glasses/goggles and protective gloves during work which may involve contact with chemicals, that is, when working with acids, pressure vessels, during cleaning, etc.!

Lip seal replacement

The lip seal on the collection system should be occasionally replaced. To do this, unscrew the pressure screw in the collection vessel, replace the used lip seal with a new one, then retighten the retaining screw (hand-tighten only).



6.3. Alignment of Pressure Measurement

Principle

Adjustment takes place according to the steam pressure curve of pure water stored in the software.

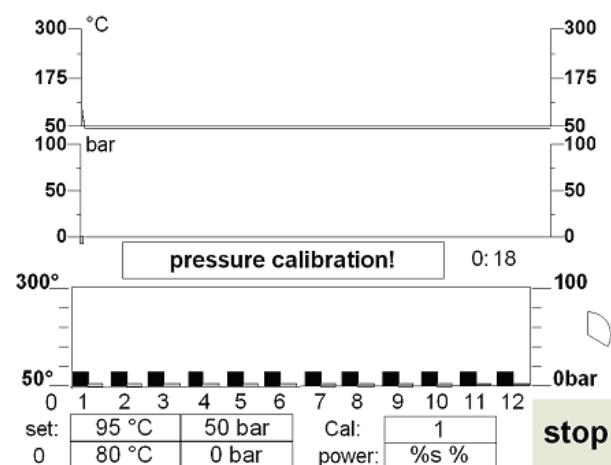
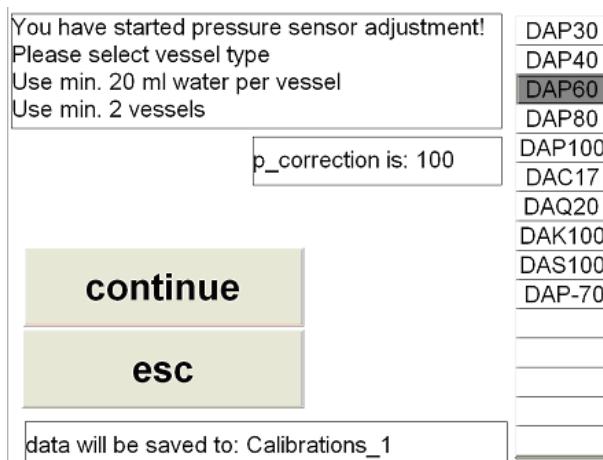
Adjustment should be repeated

- Once a month,
- After the pressure gauge lid has been dismantled (cleaning).

Implementation

Each vessel is filled with 20 ml water and sealed by means of the adjustable pressure gauge lids.

Start the **pressure adjust** program from the operator library and follow the instructions in the program.



The pressure sensor is adjusted automatically.



Note:

Adjustment can be repeated any number of times with any number of vessels. However, at least 2 vessels must be in the oven. If necessary a vessel without a pressure gauge lid must be used as the second vessel.

6.4. Output power measurement

Principle

The output power of the Magnetron has been thoroughly tested and certified by Berghof Products + Instruments before it is delivered. However all Magnetrons are subject to an aging process and it may become necessary to check the output power. This is definitely advisable if the rate at which it heats becomes significantly slower.

To measure the output power 500 ml water is heated at full microwave power for 42 seconds and then the rise in temperature established. The output power can be calculated from this.

Implementation

Start the **power test** program from the operator library and follow the instructions in the program.

microwave output power control

Place a Teflon/PP/glass beaker
filled with 500ml water in the oven.

OK

exit Open

microwave output power control

Place a Teflon/PP/glass beaker
filled with 500ml water in the oven.

OK

Measure water temperature

OK

Close door and press start
remaining time: 42 sec

Start

exit Open

microwave output power control

Place a Teflon/PP/glass beaker
filled with 500ml water in the oven.

OK

Measure water temperature

OK

Close door and press start
remaining time: 42 sec

Start

Open door, stirr water 10 s and
measure water temperature

OK

exit

Open

microwave output power control

Place a Teflon/PP/glass beaker
filled with 500ml water in the oven.

OK

Measure water temperature

OK

Close door and press start
remaining time: 42 sec

Start

Open door, stirr water 10 s and
measure water temperature

OK

Microwave power is: 950 Watt

exit

Open

The output power should be at least 900 watts.

If values of less than 800 watts are determined, the Berghof Technical Support
should be contacted (refer to 'Repairs +Customer Service').

6.5. Troubleshooting

| Fault | Possible cause | Corrective action |
|---|---|---|
| Magnetron switches off during digestion. | Magnetron overheated. Insufficient liquid Oven operated while empty. | Inform the Service Department! |
| The displayed temperature is already in excess of 80 °C immediately after the program starts. | Faulty temperature measurement Temperature sensor fault | Recalibrate the temperature offset. Recalibrate the sensor. Inform the Service Department! |
| Pressure reading too low or too high | | Realign pressure measurement Check glass parts of cap |
| Microwave fails to start. | Faulty door interlock switch. Door interlock has been manipulated. | Inform the Service Department! |
| Rupture discs activate frequently. | Corroded rupture discs Turntable not operating properly Sample amount too large Spontaneous reaction | Replace rupture discs more frequently. Check turntable operation. Reduce the sample amount. Lower the maximum temperature. |
| Rupture discs activate frequently. | Pressure reading too low | Realign pressure measurement Check glass parts of cap |
| Oven chamber and, in particular, the rotor become extremely hot. | Inadequate load (at least 5ml per vessel required). | Use larger amounts of liquid (at least 5 ml total). Reduce total running time (30 minutes max.). |
| Vessels leaking | | Spread the lip seals on the lids wider. Replace any lids repaired with PTFE seals with new lids. |
| Sparking in the oven | Inadequate load (at least 5ml per vessel required). | Use larger amounts of liquid. |
| Lid jams during closing | Turntable not engaged correctly on drive axes | Place the turntable correctly |
| FI circuit breaker in the power supply circuit trips frequently. | Faulty magnetron, short-circuit in the unit | Inform the Service Department! |

You can obtain technical support from your regional Berghof dealer or directly from Berghof Products + Instruments GmbH by contacting:

Berghof Products + Instruments GmbH
Harretstr. 1
72800 Eningen / Germany
Phone: +49/(0)7121/894-202
Fax: +49/(0)7121/894-300
E-mail: service@berghof-instruments.de

Please provide your unit's serial number with all repair questions or repair orders. The serial number is located on the nameplate.

6.6. Fuse Replacement

Unplug the power cord at the wall outlet. Unplug the fuse holder. The unit is protected by two 12.5 AT fuses. Always replace both fuses. Make sure the fuse holder is oriented in the proper direction when reinstalling it!

If the fuses again trip after being replaced, please inform the Service Department.

Procedure

- Remove the power cord. The mains plug and the fuse holder form a single unit and are located on the right side of the device. The holder contains two fuses.
- Using a screwdriver, turn the plastic screw counterclockwise until it pops out.
- The fuse holder can now be removed for fuse replacement.
- Insert a new fuse in the plastic screw and reinstall the screw in the fuse holder. Use a screwdriver to tighten the screw by turning it clockwise.



Note:

Use only OEM fuses in accordance with the description below.

Fuse type

Size: 20 x 5mm; 250 VAC; 12.5 AT
Order no.: 5001091

6.7. Repairs / Customer Service



DANGER ! The unit employs high voltage and generates microwave radiation!

Any repair and service work may only be performed by properly trained and qualified personnel.

Always unplug the unit from the power supply before beginning any repair or maintenance work.

The high voltage condenser may still carry a charge even after the mains power plug has been pulled. It must therefore be discharged by bridging the terminals, e.g., with a well insulated screwdriver. Make sure you are not in contact with any metal while discharging.

Never alter the settings of the contact switches. However, should it be necessary to do so, the proper function of the switches must be checked before the unit is again taken into service. Proper switch function must then be confirmed by measuring the unit's microwave leakage radiation. This value must lie below the limit value of < 5 mW/cm².

You can obtain technical support and information regarding spare parts (order no. and prices) from your regional Berghof dealer or directly from Berghof Products + Instruments GmbH by contacting:

Berghof Products + Instruments GmbH
Harretstr. 1
72800 Eningen / Germany
Phone: +49/(0)7121/894-202
Fax: +49/(0)7121/894-300
E-mail: service@berghof-instruments.de

Please provide your unit's serial number with all repair questions or repair orders. The serial number is located on the nameplate.

6.8. Nameplate

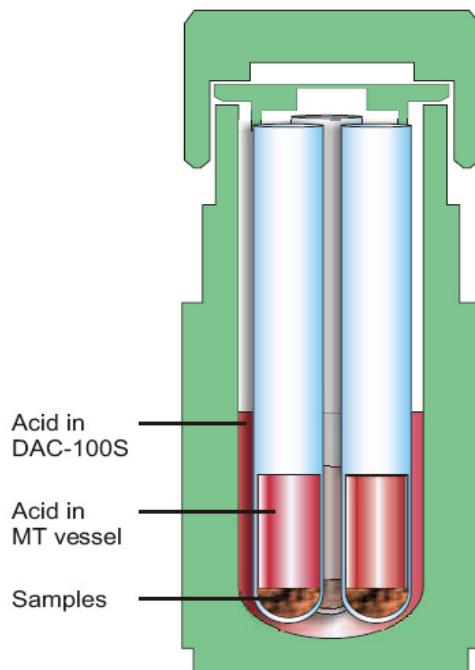
1. Manufacturer and address
2. a. CE designation
b. Microwave frequency
3. Berghof part number
4. Barcode identification no.



7. Appendix

7.1. Tips and Tricks

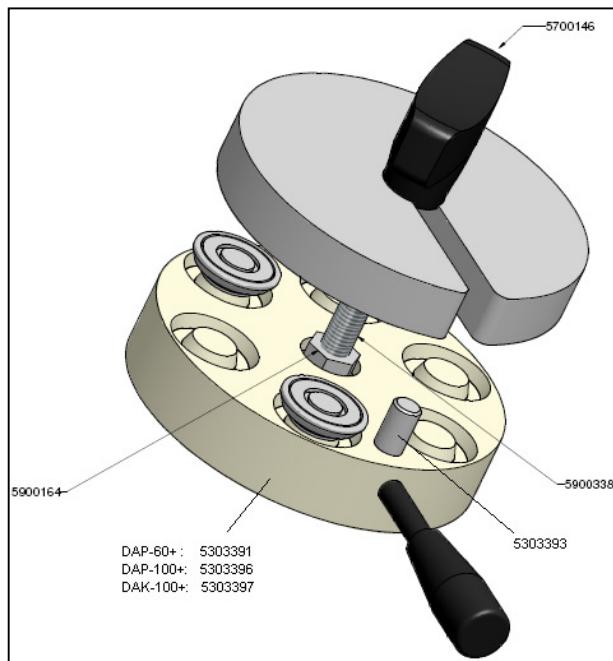
| | |
|-----------------------------|---|
| Small sample quantities | With the MT or quartz glass inserts small sample quantities <100mg can be digested in a reduced acid volume. This also makes it possible to enhance the detection sensitivity of the entire process. |
| Multiple samples per vessel | <p>The MT system makes it possible for 2-3 samples to be digested in a single DAP 100+ or DAK-100/4 digestion vessel at a reduced original sample weight and acid volume. This enables the sample throughput and productivity of the speedwave four to be raised.</p> <p>Cross-contamination from one sample to another is prevented by pre-filling the same acid mixture into the outer vessel as in the inner vessel. If the acid volume on the outside is selected so that the liquid level is higher than in the MT vessel, this also guarantees that the sample is heated up gently.</p> |



| | |
|--------------------------|--|
| Higher sample throughput | The sample throughput can also be increased by removing the vessels from the speedwave four approximately 5 minutes after completion of the last heating stage and replacing them with new samples. Therefore no time is wasted on cooling down the samples and idle time in the microwave is restricted to a minimum. |
| Cooling down samples | As a rule, the samples cool down in 15-20 min. to the point at which they can be opened. However, the cooling-down time can be reduced to 5-10 min. if the digestion vessels are placed in a water bath containing cold water. |

Dilating sealing lips

The sealing lips of maximally 6 caps can be dilated fast and simply in the 6-fold dilation tool.

Stainless steel
rupture disk

For specific applications Berghof offers stainless steel rupture disks to be used with the DAP-60+ vessels. Applications are, for example, the digestion of ROHs samples or plastic materials up to 250 mg original sample weight

TFM rupture disks

For specific applications Berghof offers TFM caps with the DAP-60+ and DAP100+ vessels, which are used without additional metallic rupture disks. Potential applications are, for example, digestions for ultra-trace analytics such as those performed in the semiconductor industry.

When using these TFM caps/rupture disks it must be borne in mind that the rupture pressure depends on the temperature and the time digestion takes. The reason for this is the reduced strength of the TFM material at higher temperatures. Metallic rupture disks do not demonstrate this dependency in the temperature range < 300 °C, which is why the standard rupture disks used at Berghof are metallic ones.

7.2. Applications

The data listed below are only to be viewed as reference values. Basically, the reaction progression depends on a series of not always predictable factors (distribution of the substances, surface area, catalytic effects of additives), so that spontaneous reactions may occur and result in activation of the rupture disc.

All applications are also available as individual documents. Please contact your local, authorized dealer or Berghof Products + Instruments GmbH (refer to the "Repairs / Customer Service" section for contact addresses).

| Sample | Weight | Vessel | Acid | Temp. | Time | File |
|--|--------|-------------------|--|--------|--------|---|
| α -Al ₂ O ₃ | 200 mg | DAC-17 | HCl, H ₂ SO ₄ , HF, HNO ₃ | 280 °C | 55 min | MWS-a-Al ₂ O ₃ .pdf |
| Activated Carbon | 50 mg | DAP-60+ | HNO ₃ | 220 °C | 45 min | MWS-Activated_Carbon.pdf |
| Al ₂ O ₃ + TiC | 10 mg | DAC-17 | HNO ₃ , HF, HCl, H ₂ SO ₄ | 280 °C | 50 min | MWS-Al ₂ O ₃ -TiC.pdf |
| Al ₂ O ₃ | 200 mg | DAP-30+ DAK-100/4 | HNO ₃ , HF | 270 °C | 60 min | MWS-Al ₂ O ₃ .pdf |
| Al ₂ O ₃ 95% | 200 mg | DAP-60+ | H ₃ PO ₄ , H ₂ SO ₄ , HF | 240 °C | 20 min | MWS-Al ₂ O ₃ 95%.pdf |
| Alloy Cr-Mo-Co | 100 mg | DAP-60+ | HNO ₃ , HCl, NH ₄ F | 200 °C | 30 min | MWS-Cr-Mo-Co-Alloy.pdf |
| Alloy Cr-Mo-Ni | 100 mg | DAP-60+ | HNO ₃ , HCl | 200 °C | 30 min | MWS-Cr-Mo-Ni-Alloy.pdf |
| Alloy Cr-Ni-Pd | 100 mg | DAP-60+ | HNO ₃ , HCl, NH ₄ F | 200 °C | 30 min | MWS-Cr-Ni-Pd-Alloy.pdf |
| Alloy Cr-W-Co | 100 mg | DAP-60+ | HCl | 200 °C | 30 min | MWS-Cr-W-Co-Alloy.pdf |
| Alloy Fe-Nb | 50 mg | DAP-60+ | HCl, HF, HNO ₃ | 240 °C | 35 min | MWS-Fe-Nb-Alloy.pdf |
| Alloy Fe-Ti | 50 mg | DAP-60+ | HCl, HF, HNO ₃ | 220 °C | 45 min | MWS-Fe-Ti-Alloy.pdf |
| Alloy Pt-Ir | 50 mg | DAK-100/4 | HNO ₃ , HCl | 200 °C | 45 min | MWS-Pt-Ir-Alloy.pdf |
| Alloy Rh-Ir | 300 mg | DAK-100/4 | HCl, H ₂ O ₂ , H ₂ SO ₄ | 250 °C | 65 min | MWS-Rh-Ir-Alloy.pdf |
| Alloys Pt-Ir | 100 mg | DAK-100/4 | HCl, HNO ₃ , Br ₂ | 210 °C | 45 min | MWS-Pt-Ir-Alloys.pdf |
| Aluminium | 150 mg | DAP-60+ | HNO ₃ , HCl | 175 °C | 20 min | MWS-Aluminium.pdf |
| Ash | 200 mg | DAP-60+ | HNO ₃ , HF | 200 °C | 45 min | MWS-Ash-B.pdf |
| Ash | 300 mg | DAP-60+ | HNO ₃ , HF, HCl | 220 °C | 33 min | MWS-Ash-A.pdf |
| Asphaltite | 200 mg | DAK-100/4 | HNO ₃ , HF | 200 °C | 75 min | MWS-Asphaltite.pdf |

| Sample | Weight | Vessel | Acid | Temp. | Time | File |
|--------------------------------|--------|-----------------|---|--------|--------|--------------------------|
| Bakelite | 500 mg | DAP-60+ | HNO ₃ , HCl | 180 °C | 35 min | MWS-Bakelite.pdf |
| Bark | 500 mg | DAP-60+ | HNO ₃ , HCl | 200 °C | 35 min | MWS-Bark.pdf |
| Bauxite | 50 mg | DAP-60+ | HNO ₃ , H ₃ PO ₄ , HCl | 250 °C | 50 min | MWS-Bauxite.pdf |
| Beet Roots | 300 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 190 °C | 25 min | MWS-Beet-Roots.pdf |
| Blood | 2 ml | DAP-60+ /DAQ-20 | HNO ₃ | 190 °C | 15 min | MWS-Blood.pdf |
| Body Lotion | 300 mg | DAP-60+ | HNO ₃ | 190 °C | 35 min | MWS-Body Lotion.pdf |
| Bones | 300 mg | DAP-60+ | HNO ₃ , HCl | 190 °C | 30 min | MWS-Bone.pdf |
| Boron Carbide B ₄ C | 100 mg | DAK-100/4 | HNO ₃ , HF, H ₂ SO ₄ | 220 °C | 30 min | MWS-B4C.pdf |
| Bran | 400 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 190 °C | 20 min | MWS-Bran.pdf |
| Brass | 100 mg | DAP-60+ | HNO ₃ | 210 °C | 30 min | MWS-Brass-B.pdf |
| Brass | 100 mg | DAP-60+ | HNO ₃ , HF | 180 °C | 30 min | MWS-Brass-A.pdf |
| Bronze | 100 mg | DAP-60+ | HNO ₃ , HF | 180 °C | 30 min | MWS-Bronze-A.pdf |
| Bronze | 100 mg | DAP-60+ | HNO ₃ | 210 °C | 30 min | MWS-Bronze-B.pdf |
| Cacao | 300 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 190 °C | 25 min | MWS-Cacao.pdf |
| Calcites+Dolomite | 100 mg | DAP-60+ | HNO ₃ , HF | 200 °C | 45 min | MWS-Calcite-Dolomite.pdf |
| Caoutchouc | 250 mg | DAP-60+ | HNO ₃ | 200 °C | 60 min | MWS-Caoutchouc.pdf |
| Car Catalyst | 50 mg | DAP-30+ | HCl, H ₃ PO ₄ | 260 °C | 45 min | MWS-Car-Catalyst.pdf |
| Catalyst | 150 mg | DAK-100/4 | HNO ₃ , HCl, HF | 220 °C | 60 min | MWS-Catalyst.pdf |
| Cement | 300 mg | DAP-60+ | HNO ₃ , HCl, HF | 210 °C | 15 min | MWS-Cement.pdf |
| Cigarette | 300 mg | DAP-60+ | HNO ₃ , HCl | 210 °C | 25 min | MWS-Cigarette.pdf |
| Clay | 100 mg | DAP-60+ | HNO ₃ , HF | 210 °C | 30 min | MWS-Clay.pdf |
| Coal | 150 mg | DAP-60+ | HNO ₃ , HF | 200 °C | 20 min | MWS-Coal.pdf |
| Coal | 400 mg | DAK-100/4 | HNO ₃ , HF | 200 °C | 70 min | MWS-Coal-B.pdf |
| Coal Fly Ash | 250 mg | DAK-100/4 | HNO ₃ , HF | 200 °C | 35 min | MWS-Coal-Fly-Ash.pdf |
| Cobalt Tungstate | 100 mg | DAP-60+ | HNO ₃ , HF | 240 °C | 65 min | MWS-Cobalt Tungsta- |

| Sample | Weight | Vessel | Acid | Temp. | Time | File |
|--|--------|-----------------|--|--------|--------|--------------------------|
| | | | | | | te.pdf |
| Coffee | 400 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 180 °C | 15 min | MWS-Coffee-B.pdf |
| Coffee | 300 mg | DAP-60+ | HNO ₃ | 200 °C | 12 min | MWS-Coffee-A.pdf |
| Cognac | 500 µl | DAP-60+ | HNO ₃ , H ₂ O ₂ | 160 °C | 20 min | MWS-Cognac.pdf |
| Coke | 100 mg | DAC-17 | HNO ₃ , H ₂ SO ₄ | 260 °C | 40 min | MWS-Coke.pdf |
| Copper Wire | 500 mg | DAK-100/4 | HNO ₃ | 190 °C | 20 min | MWS-Copper-wire.pdf |
| Dolomites + Calcites | 100 mg | DAP-60+ | HNO ₃ , HF | 200 °C | 45 min | MWS-Calcite-Dolomite.pdf |
| Dried Plants | 300 mg | DAP-60+ | H ₂ SO ₄ , H ₂ O ₂ | 190 °C | 10 min | MWS-Plants-C.pdf |
| Dried Plants | 400 mg | DAP-60+ | HNO ₃ | 190 °C | 15 min | MWS-Plants-A.pdf |
| Electronic Parts | 500 mg | DAP-60+ | HNO ₃ , H ₂ SO ₄ | 175 °C | 20 min | MWS-electronic parts.pdf |
| EVA Foam | 400 mg | DAK-100/4 | HNO ₃ | 190 °C | 20 min | MWS-EVA-Foam.pdf |
| EVOH ethylene vinyl alcohol copolymer resins | 500 mg | DAK-100/4 | HNO ₃ | 180 °C | 15 min | MWS-EVOH.pdf |
| Face Creme | 250 mg | DAP-60+ DAQ-20H | HNO ₃ | 190 °C | 35 min | MWS-Face Creme.pdf |
| Feldspar | 250 mg | DAK-100/4 | HCl, HF, H ₃ BO ₃ | 200 °C | 35 min | MWS-Feldspar.pdf |
| Flour | 400 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 190 °C | 20 min | MWS-Farine.pdf |
| Fatty Acid of Coconut | 200 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 170 °C | 15 min | MWS-Coconut Fat Acid.pdf |
| Feed | 300 mg | DAP-60+ | HNO ₃ , HBF ₄ | 215 °C | 15 min | MWS-Feed-B.pdf |
| Feed | 300 mg | DAP-60+ | HNO ₃ | 230 °C | 15 min | MWS-Feed-A.pdf |
| Fishmeal | 500 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 200 °C | 40 min | MWS-Fishmeal.pdf |
| Fly Ash | 50 mg | MT | HNO ₃ , HF, H ₂ SO ₄ | 220 °C | 40 min | MWS-Fly-Ash.pdf |
| Food | 500 mg | DAP-40+ | HNO ₃ | 190 °C | 25 min | MWS-DAP-40-Food.pdf |
| Fruite Juices | 5 ml | DAP-100+ | HNO ₃ , H ₂ O ₂ | 200 °C | 25 min | MWS-Fruite-Juice.pdf |
| Fruites (dried) | 250 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 210 °C | 25 min | MWS-Fruits.pdf |

| Sample | Weight | Vessel | Acid | Temp. | Time | File |
|-----------------------------------|--------|----------------|--|--------|--------|-------------------------------|
| Garnet | 100 mg | DAP-60+ | HNO ₃ , HF, H ₃ BO ₃ | 245 °C | 45 min | MWS-Garnet.pdf |
| Gas Coal | 150 mg | DAK-100/4 | HNO ₃ , HF, H ₃ BO ₃ | 200 °C | 35 min | MWS-Gas-Coal.pdf |
| Gingseng | 500 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 190 °C | 30 min | MWS-Gingseng.pdf |
| Grab paste | 300 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 190 °C | 30 min | MWS-Grab_Paste.pdf |
| Hair | 250 mg | DAP-60+ DAQ-20 | HNO ₃ | 190 °C | 20 min | MWS-Hair.pdf |
| Hardmetal Scrap | 100 mg | DAP-60+ | HNO ₃ , HF | 240 °C | 65 min | MWS-Hardmetal Scrap.pdf |
| Herbs | 500 mg | DAK-100/4 | HNO ₃ , H ₂ O ₂ | 210 °C | 30 min | MWS-Herbs.pdf |
| Ink | 250 mg | DAP-60+ | HNO ₃ | 200 °C | 30 min | MWS-Ink.pdf |
| In-Sn-Oxides | 500 mg | DAP-60+ | HCl, HF, H ₃ BO ₃ | 190 °C | 25 min | MWS-In-Sn-Oxide.pdf |
| Ionomer | 100 mg | DAP-60+ | HNO ₃ | 190 °C | 35 min | MWS-Ionomer.pdf |
| Iron Ores | 100 mg | DAP-60+ | H ₂ SO ₄ , H ₃ PO ₄ , HF | 240 °C | 30 min | MWS-Iron-Ores.pdf |
| Ironstone | 100 mg | DAP-60+ | HNO ₃ , HCl | 220 °C | 50 min | MWS-Ironstone.pdf |
| Kaolinit | 100 mg | DAP-60+ | H ₂ SO ₄ , HF | 240 °C | 50 min | MWS-Kaolinit.pdf |
| LaB ₆ Lanthanum boride | 200 mg | DAK-100/4 | HNO ₃ | 230 °C | 10 min | MWS-LaB6.pdf |
| Laboratory Dust | 75 mg | DAP-60+ | HNO ₃ , HF | 200 °C | 15 min | MWS-Dust.pdf |
| Lead Zirconate Titanate | 100 mg | DAP-60+ | HNO ₃ , HF | 240 °C | 65 min | MWS-LeadZirconateTitanate.pdf |
| Lime | 300 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 190 °C | 20 min | MWS-Lime.pdf |
| Limestone | 150 mg | DAK-100/4 | HCl, HF | 220 °C | 20 min | MWS-Limestone.pdf |
| Line Seed | 500 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 190 °C | 15 min | MWS-Line-Seed-A.pdf |
| Line Seed | 400 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 180 °C | 15 min | MWS-Line-Seed-B.pdf |
| Lipstick | 250 mg | DAP-60+ | HNO ₃ , HF | 190 °C | 35 min | MWS-Lipstick.pdf |
| Lithium Titanates | 100 mg | DAP-60+ | HNO ₃ , HF | 200 °C | 35 min | MWS-LithiumTitanate.pdf |

| Sample | Weight | Vessel | Acid | Temp. | Time | File |
|---------------------------------------|----------|-----------|--|--------|--------|--------------------------------|
| Milk Powder | 500 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 190 °C | 30 min | MWS-Milk-Powder-D.pdf |
| Milk Powder | 200 mg | DAP-60+ | HNO ₃ | 200 °C | 30 min | MWS-Milk-Powder-A.pdf |
| Monomer | 500 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 200 °C | 35 min | MWS-Monomer.pdf |
| Muffins | 1,000 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 170 °C | 25 min | MWS-Muffin.pdf |
| Multivitamin and Multielement Tablets | 1,000 mg | DAK-100/4 | HNO ₃ , H ₂ O ₂ | 210 °C | 50 min | MWS-Multiitamin-Tablets.pdf |
| Niobiumdisulfide | 200 mg | DAP-60+ | HNO ₃ , HF | 245 °C | 25 min | MWS-NbS2.pdf |
| NIST 1633 | 50 mg | DAP-60+ | HNO ₃ , HF | 200 °C | 45 min | MWS-Nist-1633.pdf |
| Nylon | 400 mg | DAK-100/4 | HNO ₃ , H ₂ SO ₄ | 190 °C | 35 min | MWS-Nylon.pdf |
| Oils | 100 mg | DAP-60+ | HNO ₃ , HCl, HF | 180 °C | 30 min | MWS-Oil-B.pdf |
| Oils | 100 mg | DAP-60+ | HNO ₃ , HF | 190 °C | 35 min | MWS-Oil-A.pdf |
| Olive Leaves | 500 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 190 °C | 30 min | MWS-Olive Leave.pdf |
| Vegetable Oil | 700 mg | DAK-100/4 | HNO ₃ , H ₂ O ₂ | 210 °C | 30 min | MWS-Vegetable-Oil.pdf |
| Paint | 0,75 ml | DAK-100/4 | HNO ₃ , H ₂ O ₂ | 190 °C | 35 min | MWS-Paint.pdf |
| Palmnut Flakes | 300 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 190 °C | 25 min | MWS-Palmnut-Flakes.pdf |
| Paprika Powder | 300 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 180 °C | 15 min | MWS-Paprika-B.pdf |
| Paprika Powder | 300 mg | DAP-60+ | HNO ₃ | 200 °C | 15 min | MWS-Paprika-A.pdf |
| PEEK | 100 mg | DAP-60+ | HNO ₃ , H ₂ SO ₄ | 220 °C | 15 min | MWS-PEEK.pdf |
| PET | 250 mg | DAP-60+ | HNO ₃ , H ₂ SO ₄ | 220 °C | 35 min | MWS-PET-C.pdf |
| PET | 150 mg | DAP-60+ | HNO ₃ , H ₂ SO ₄ | 225 °C | 45 min | MWS-PET-B.pdf |
| Petrol Coke | 300 mg | DAK-100/4 | HNO ₃ , H ₂ SO ₄ , HF | 250 °C | 70 min | MWS-Petrolcoke.pdf |
| Pharma Raw Materials | 250 mg | DAK-100/4 | HNO ₃ | 210 °C | 30 min | MWS-Raw-Materials-Pharma.pdf |
| Pharma Raw Materials | 250 mg | DAK-100/4 | HNO ₃ , H ₂ O ₂ | 210 °C | 30 min | MWS-Raw-Materials-Pharma-B.pdf |
| Phosphate Rocks | 200 mg | DAP-60+ | HNO ₃ , HF, H ₃ BO ₃ | 220 °C | 25 min | MWS-Phosphate_rock.pdf |

| Sample | Weight | Vessel | Acid | Temp. | Time | File |
|------------------------|----------|-----------|---|--------|--------|---|
| Platinum Ores | 50 mg | DAP-60+ | HNO ₃ , H ₂ SO ₄ , H ₃ PO ₄ , HF | 240 °C | 65 min | MWS-Platinum Ore.pdf |
| Polyester | 250 mg | DAP-60+ | HNO ₃ , H ₂ SO ₄ | 215 °C | 40 min | MWS-Polyester-A.pdf |
| Polyethylene PE | 150 mg | DAP-60+ | HNO ₃ , H ₂ SO ₄ | 220 °C | 45 min | MWS-PE-A.pdf |
| Polyethylene PE | 300 mg | DAP-60+ | HNO ₃ , HCl | 220 °C | 40 min | MWS-PE-B.pdf |
| Polyethylene PE (Film) | 200 mg | DAP-60+ | HNO ₃ , HF | 170 °C | 40 min | MWS-PE-Film.pdf |
| Polypropylene PP | 250 mg | DAP-60+ | HNO ₃ , H ₂ SO ₄ | 200 °C | 30 min | MWS-PP-A.pdf |
| PVC-Granules | 750 mg | DAK-100/4 | HNO ₃ , H ₂ O ₂ , H ₂ SO ₄ | 210 °C | 50 min | MWS-PVC-B.pdf |
| Quartz and Glass | 500 mg | DAP-60+ | HNO ₃ , HF | 200 °C | 30 min | MWS-Glass-Quartz-A.pdf |
| Quartz and Glass | 500 mg | DAP-60+ | HNO ₃ , HF, HBF ₄ | 200 °C | 30 min | MWS-Glass-Quartz-B.pdf |
| Refractory Material | 100 mg | DAP-60+ | H ₃ PO ₄ , H ₂ SO ₄ , HF, HNO ₃ | 240 °C | 30 min | MWS-Cr ₂ O ₃ -FeO-Al ₂ O ₃ .pdf |
| Refractory Material | 100 mg | DAP-60+ | H ₃ PO ₄ , H ₂ SO ₄ , HF | 240 °C | 75 min | MWS-Refractory.pdf |
| Rhodium | 100 mg | DAK-100/4 | HCl, HNO ₃ , Br ₂ | 210 °C | 45 min | MWS-Rh.pdf |
| Rice | 1,000 mg | DAP-60+ | HNO ₃ , H ₂ O ₂ | 180 °C | 30 min | MWS-Rice.pdf |
| Rubber | 250 mg | DAP-60+ | HNO ₃ | 200 °C | 60 min | MWS-Rubber.pdf |
| Secondary Fuel | 200 mg | DAK-100/4 | HNO ₃ , H ₂ SO ₄ , HF | 250 °C | 70 min | MWS-Secondary fuel.pdf |
| Sediment | 1,000 mg | DAP-60+ | HNO ₃ , HCl, HF | 175 °C | 30 min | MWS-Sediment-D.pdf |
| Sediment | 1,000 mg | DAP-60+ | HNO ₃ , HCl | 175 °C | 10 min | MWS-Sediment-E.pdf |
| Sediment | 1,000 mg | DAP-60+ | HNO ₃ , HF | 175 °C | 30 min | MWS-Sediment-A.pdf |
| Sewage Sludge | 500 mg | DAP-100+ | HNO ₃ , HCl, HF | 175 °C | 30 min | MWS-Sludge-F.pdf |
| Sewage Sludge | 500 mg | DAP-100+ | HNO ₃ , HCl | 175 °C | 30 min | MWS-Sludge-E.pdf |
| Sewage Sludge | 500 mg | DAP-100+ | HNO ₃ , HF | 175 °C | 30 min | MWS-Sludge-D.pdf |

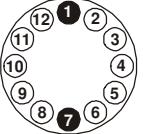
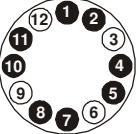
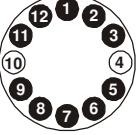
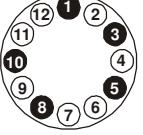
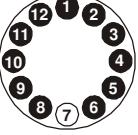
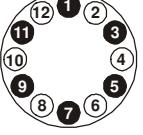
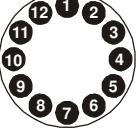
| Sample | Weight | Vessel | Acid | Temp. | Time | File |
|---|----------|-------------------|--|--------|--------|---|
| Sewage Sludge | 500 mg | DAK-100/4 | HNO3 | 180 °C | 40 min | MWS-Sludge-B.pdf |
| Sewage Sludge | 250 mg | DAP-100+ | HNO3 | 180 °C | 40 min | MWS-Sludge-A.pdf |
| Shampoo | 300 mg | DAP-60+ | HNO3 | 190 °C | 35 min | MWS-Shampoo.pdf |
| Shoe Sole | 200 mg | DAP-60+ | HNO3, HF | 220 °C | 30 min | MWS-Shoe-sole.pdf |
| Shredded Paper | 500 mg | DAP-60+ | HNO3 | 170 °C | 10 min | MWS-Paper.pdf |
| Silicon | 300 mg | DAP-60+ | HNO3, HF | 185 °C | 10 min | MWS-Silicon.pdf |
| Silicon Carbide SiC | 50 mg | DAC-17 | HNO3, HF, H ₂ SO ₄ | 290 °C | 70 min | MWS-SiC.pdf |
| SiO ₂ + Al ₂ O ₃ | 100 mg | DAP-60+ | H ₃ PO ₄ , H ₂ SO ₄ , HF, HNO ₃ | 240 °C | 30 min | MWS-SiO ₂ -Al ₂ O ₃ .pdf |
| SiO ₂ + Al ₂ O ₃ + B ₂ O ₃ | 100 mg | DAP-30+ DAK-100/4 | HF, H ₃ PO ₄ , HCl | 250 °C | 25 min | MWS-SiAlB-Oxide.pdf |
| SiO ₂ + Al ₂ O ₃ + ZrO ₂ | 150 mg | DAP-30+ DAK-100/4 | HF, H ₃ PO ₄ , HCl | 240 °C | 25 min | MWS-SiAlZr-Oxide.pdf |
| Slag (Blast Furnace) | 100 mg | DAP-60+ | HNO ₃ , HF | 200 °C | 45 min | MWS-Slag-Blast-Furnace.pdf |
| Slag (Electric Furnace) | 100 mg | DAP-60+ | H ₃ PO ₄ , H ₂ SO ₄ , HF | 240 °C | 75 min | MWS-Slag-Electric-Furnace.pdf |
| Slag + Fly Ash | 100 mg | DAP-60+ | HNO ₃ , HF | 240 °C | 65 min | MWS-Slag + Fly Ash.pdf |
| Soap | 250 mg | DAP-60+ | HNO ₃ , HF | 190 °C | 35 min | MWS-Soap.pdf |
| Soil | 4,000 mg | DAP-100+ | HNO ₃ , HF | 175 °C | 20 min | MWS-Soil-EPA3051A.pdf |
| Soil | 4,000 mg | DAP-100+ | HNO ₃ , HCl | 180 °C | 25 min | MWS-Soil-A.pdf |
| Soil | 1,000 mg | DAP-100+ | HNO ₃ , HCl | 140 °C | 15 min | MWS-Soil-B.pdf |
| Sugar | 600 mg | DAK-100/4 | HNO ₃ , H ₂ O ₂ | 190 °C | 25 min | MWS-Sugar-B.pdf |
| Sun Protection Creme | 350 mg | DAP-30+ DAK-100/4 | HNO ₃ , HF, HCl | 220 °C | 25 min | MWS-SunProtectionCreme.pdf |
| Talcum Powder | 250 mg | DAK-100/4 | HNO ₃ , HF | 210 °C | 35 min | MWS-Talcum.pdf |
| Tar | 500 mg | DAK-100/4 | HNO ₃ | 210 °C | 30 min | MWS-Tar-pdf |
| Tea | 500 mg | DAK-100/4 | HNO ₃ | 190 °C | 40 min | MWS-Tea.pdf |

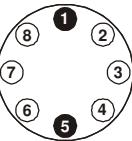
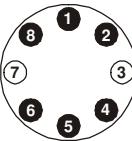
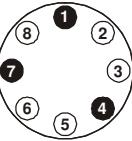
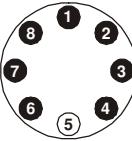
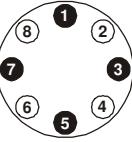
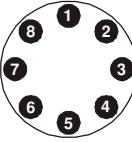
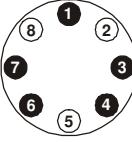
| Sample | Weight | Vessel | Acid | Temp. | Time | File |
|------------------------------------|----------|----------------|---|--------|--------|-----------------------------|
| Textiles | 300 mg | DAP-60+ | HNO3 | 190 °C | 15 min | MWS-Textiles.pdf |
| TiB ₂ Titanium Boride | 100 mg | DAK-100/4 | HNO3, HCl, HF | 230 °C | 30 min | MWS-TiB2-pdf |
| Tinctures | 500 mg | DAP-60+ | HNO3, H ₂ O ₂ | 190 °C | 30 min | MWS-Tinctures.pdf |
| Tire body | 200 mg | DAP-60+ | HNO3 | 230 °C | 55 min | MWS-Tire-Body.pdf |
| Tissue | 250 mg | DAP-60+ DAQ-20 | HNO3 | 190 °C | 20 min | MWS-Tissue.pdf |
| Titanium Carbide | 200 mg | DAK-100/4 | HNO3, HF | 245 °C | 25 min | MWS-TiC-A.pdf |
| Titanium Carbide | 200 mg | DAK-100/4 | HNO3, H ₂ SO ₄ | 190 °C | 25 min | MWS-TiC-B.pdf |
| Titanium Disulfide | 200 mg | DAK-100/4 | HNO3, HF | 245 °C | 25 min | MWS-TiS2.pdf |
| Tomato Leaves | 500 mg | DAP-60+ | HNO3, H ₂ O ₂ | 190 °C | 30 min | MWS-Tomato-Leaves-B.pdf |
| Toothpaste | 250 mg | DAP-60+ | HNO3, HF | 190 °C | 35 min | MWS-Toothpaste.pdf |
| Tungsten | 300 mg | DAK-100/4 | HNO3, HCl, HF | 250 °C | 60 min | MWS-tungsten.pdf |
| Vanilla Dessert | 400 mg | DAP-60+ | HNO3 | 200 °C | 15 min | MWS-Vanilla-Dessert.pdf |
| Vegetables | 400 mg | DAP-60+ | HNO3, H ₂ O ₂ | 200 °C | 25 min | MWS-Vegetables.pdf |
| Water, Effluents | 30 ml | DAP-100+ | H ₂ SO ₄ , K ₂ S ₂ O ₈ | 200 °C | 20 min | MWS-Effluents-P.pdf |
| Water, Effluents | 30 ml | DAP-100+ | HNO3, H ₂ O ₂ | 200 °C | 20 min | MWS-Effluents-HM-A.pdf |
| Water, Effluents | 30 ml | DAP-100+ | HNO3, HCl | 180 °C | 25 min | MWS-Effluents-HM-B.pdf |
| Water, Effluents | 20 ml | DAP-100+ | NaOH, K ₂ S ₂ O ₈ | 200 °C | 20 min | MWS-Water-P-N.pdf |
| Wax | 300 mg | DAP-60+ | HNO3 | 240 °C | 30 min | MWS-Wax.pdf |
| Glass Fiber Filters (Whatman 934H) | | DAP-100+ | HNO3, HF, H ₃ BO ₃ | 180 °C | 35 min | MWS-glass-filters.pdf |
| Vessel Cleaning | | all types | HNO3, HCl | 200 °C | 20 min | MWS-Vessel-Cleaning.pdf |
| Vessel Conditioning | | all types | | 250 °C | 12 h | MWS-vessel-conditioning.pdf |
| Wheat | 1,000 mg | DAP-60+ | HNO3, H ₂ O ₂ | 170 °C | 25 min | MWS-Wheat.pdf |

| Sample | Weight | Vessel | Acid | Temp. | Time | File |
|-----------------|--------|-----------|--|--------|--------|--------------------------|
| Whey-Powder | 500 mg | DAK-100/4 | HNO ₃ , H ₂ O ₂ | 210 °C | 30 min | MWS-Whey-Powder.pdf |
| WO ₃ | 600 mg | DAK-100/4 | HNO ₃ , HF | 175 °C | 35 min | MWS-WO ₃ .pdf |
| Wood | 600 mg | DAP-60+ | HNO ₃ | 150 °C | 15 min | MWS-Wood-A.pdf |
| Wood chips | 500 mg | DAK-100/4 | HNO ₃ , HF | 200 °C | 30 min | MWS-Wood-B.pdf |
| Yogurt | 500 mg | DAK-100/4 | HNO ₃ , HCl | 190 °C | 25 min | MWS-yogurt.pdf |
| Zeolites | 100 mg | DAP-60+ | HNO ₃ , HCl, HF | 240 °C | 20 min | MWS-Zeolite.pdf |
| Zinc Oxide | 500 mg | DAP-60+ | HNO ₃ , HF | 210 °C | 30 min | MWS-Zinc Oxide.pdf |

7.2.1. Positioning of Vessels in the Turntable

In the following figures the optimal positioning of the vessels in the rotor is illustrated.

| DAP-Vessels | Sample number | Position in rotor | Sample number | Position in rotor |
|-------------|---------------|---|---------------|---|
| | 2 |  | 8 |  |
| | 3 |  | 9 |  |
| | 4 |  | 10 |  |
| | 5 |  | 11 |  |
| | 6 |  | 12 |  |
| | 7 |  | | |

| DAC-100 vessels | Sample number | Position in rotor | Sample number | Position in rotor |
|-----------------|---------------|--|---------------|---|
| | 2 |  | 6 |  |
| | 3 |  | 7 |  |
| | 4 |  | 8 |  |
| | 5 |  | | |

7.3. Conformity Declaration

Declaration of CE-Conformity

Manufacturer: BERGHOF Products + Instruments GmbH
Labor-Technik
Harretstraße 1
D - 72800 Eningen

Product: Digestion System **speedwave four**
Part no. 5304000
Start-up packages **speedwave four**
Part no. 5304910, 5304920, 5304930,
5304940, 5304950

This product meets the limit values for the following norms of the european community:

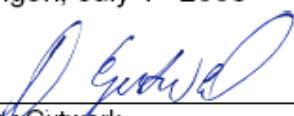
DIN EN 61010-1 (IEC 1010-1)
DIN EN 61326-1
DIN EN 61326-2

The unit is suited for installation in business and commercial areas and small businesses. Installation in an industrial area can lead to disturbances in the unit.

Issuer: BERGHOF Products + Instruments GmbH

Date: Eningen, July 1st 2008

Signature:



Dieter Gutwerk
- Manager Labor-Technik -

7.4. Conversion Table

| | | |
|--------------------|----------------------|---|
| Temperature | $^{\circ}\text{C} =$ | $(^{\circ}\text{F} - 32^{\circ}) / 1.8$ |
| | $^{\circ}\text{F} =$ | $1.8 * ^{\circ}\text{C} + 32^{\circ}$ |
| Length | $1 \text{ cm} =$ | 0.3937 inch |
| | $1 \text{ inch} =$ | 2.540 cm |
| Volume | $1 \text{ ml} =$ | $0.06102 \text{ inch}^3 = 2.642 * 10^{-4} \text{ gallon}$ |
| | $1 \text{ inch}^3 =$ | $16.387 \text{ ml} = 43.29 * 10^{-4} \text{ gallon}$ |
| | $1 \text{ gallon} =$ | $3785 \text{ ml} = 231 \text{ inch}^3$ |
| Pressure | $1 \text{ bar} =$ | 14.504 psi = 0.1 Mpa |
| | $1 \text{ psi} =$ | 0.06895 bar = 0.0068948 Mpa |
| | $1 \text{ Mpa} =$ | 10 bar = 145.04 psi |
| Weight | $1 \text{ kg} =$ | 2.2046 lb. |
| | $1 \text{ lb.} =$ | 0.4536 kg |